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THREE PHILIPPINE ANOPHELES OF THE FUNESTUS-MINIMUS SUBGROUP [1]

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TWO PLATES AND EIGHT TEXT FIGURES

The species now generally known as *Anopheles minimus* has been recorded from the Philippines under a variety of names since 1904. The occurrence on Luzon Island of a second larval form, with frayed or branched instead of simple clypeal hairs, has also been known to the local workers since about 1924.[2]

At the time of my first trip to the Philippines in 1929, adult characters corresponding to this second type had not been fully worked out, and as the two kinds of larvæ had always been found together it was still considered questionable whether they were not merely variations of one species. Specimen material for a detailed study of the two forms was collected during the first four months of that year, but comparative material from other regions was lacking and the matter of names applicable to the species could not be satisfactorily settled in the time then available.

[1] The studies were conducted with the support and under the auspices of the International Health Division of the Rockefeller Foundation, in coöperation with the Philippine Bureau of Science, the Philippine Health Service, and the United States Bureau of Entomology.

[2] From studies made by W. D. Tiedeman and F. E. Baisas. A description of the larva of *A. minimus*, with the variations found in the branching of the clypeal hairs, was published by Baisas in 1927.

In the meantime, Manalang (1930) has published a partial description of these two forms and, following Strickland (1924), has come to the conclusion that *Anopheles minimus* is identical with the African *funestus*. The second species, with branched clypeal hairs, was believed by him to be related to *Anopheles aconitus* and was described as *Anopheles aconitus* var. *filipinæ*.

In regard to the position of *A. minimus*, Evans (1930), Puri (1930), and Christophers and Puri (1931) have pointed out a number of differences between it and *A. funestus*. To these I can now add several others, in larval as well as male genitalic characters, and since these differences impress one as being more distinctive, if anything, than those separating some of the other members of the group (for example *filipinæ* and *minimus*) the specific identity of *minimus* can hardly be doubted.

With reference to var. *filipinæ*, Manalang (p. 258) states that when there are two interruptions on the basal third of the wing costa "it is surely *aconitus*" (that is, var. *filipinæ*), and in giving the variety a new name he evidently overlooked the fact that two species with this particular character have previously been described from the Philippines, namely, *Myzomyia mangyana* Banks and *Myzomyia febrifera* Banks.

The presence of such spots is indicated in the original description of *M. mangyana* (as noted by Christophers, 1924, p. 50) and their occurrence on *M. febrifera*, though not given by Banks, is indicated by Walker and Barber in an article published the same year [1914 p. 385 "front edge (of wing) black, with 5 yellow spots and a pale-yellow tip"]. The type specimens of the two species, still available in the Bureau of Science collection at Manila, show the two white spots toward the base of the costa and, as *filipinæ* was not differentiated from either of these, it was to be concluded that the name constituted another synonym.

Upon finally working up my own accumulated material, however, I find that three species, instead of two, are distinguishable in the Philippine fauna. As a consequence, the disposition of the names becomes more complicated since the third species also has a double interruption at the base of the costa.

The information available on the subject and the conclusions reached are more fully discussed in a later part of the paper but may be briefly stated here.

Myzomyia mangyana was described in 1906 from specimens collected by Mr. R. C. McGregor at Chicago, Rio Baco, Mindoro

(an island just to the southwest of Luzon), and several female specimens from this lot remain in the Bureau of Science collection. Although the specimens are mostly in poor condition, they have plainly marked costal white spots over the humeral crossvein in addition to the usual presector white spots.

Myzomyia febrifera was described by the same author in 1914 from specimens furnished by E. L. Walker and M. A. Barber from Canlubang, Laguna Province, Luzon. The author makes no reference to his previously described species, or to Ludlow's *M. flavirostris* also described in 1914.

In 1915, Miss Ludlow expressed her belief that only one form was present in the Islands, and, from the adult characters as described, all three names have since been regarded as synonyms of *A. minimus*. Banks evidently accepted this synonymy as he has made no subsequent effort to establish his species as distinct. Furthermore, his *febrifera* identifications in the Bureau of Science collection include at least two forms, so his grounds for separating the species originally are decidedly obscure.

Nevertheless, after a careful examination of all the material in the collection, I am reasonably sure that the type of *M. febrifera* and most of the other specimens from the same source do correspond to the third species as defined here. The position of *M. mangyana* is less definite since the type specimen might be either *febrifera* or *filipinæ* so far as the markings can be made out. The matter could possibly be settled more conclusively by a re-study of the type locality, which unfortunately is rather inaccessible and has not been visited. I am, however, of the opinion that it is the same as *febrifera*, judging by the environment in which it was collected (recently described to me by Mr. McGregor), by the presence of the humeral spots on each of six specimens, a percentage of occurrence that would be unusual for *filipinæ*, and by the probable absence of fringe spots at vein 6.

For the present, therefore, the name *filipinæ* is retained and the name *mangyanus* is assigned to the third species, *febrifera* becoming a synonym of the latter.

Our commonest form, corresponding more closely to typical *minimus*, differs in certain respects from specimens obtained in the type locality (Hong Kong) and is treated in the present paper as a variety, *Anopheles minimus* var. *flavirostris* Ludlow.

In connection with the findings referred to, it may be recalled that the species ("*Anopheles febrifer*"), which Walker and Bar-

ber found to be highly susceptible to laboratory infection with malaria parasites, has always been regarded as *Anopheles minimus.* The probability that most of their material was not *minimus* (or its Philippine variety) is accordingly of considerable importance. Moreover, the two forms have almost certainly been confused to a greater or lesser extent in field studies connecting *minimus* with malaria transmision under natural conditions. The occurrence of *mangyanus* on Luzon now appears to coincide with a recognized "malarious type" of country somewhat more closely than does that of var. *flavirostris* since the latter is known to be present in nonmalarious areas, and the question of another important carrier in the Philippines must therefore be taken into consideration.

ASSOCIATION OF SPECIES AND GENERAL BREEDING CONDITIONS

The three Philippine species are all typically small-stream breeders, and the collections frequently show *minimus* (var. *flavirostris*) associated with one of the other two.

Larvæ of *filipinæ* have usually been taken merely as occasional specimens in the *minimus* collections, but several places have been observed in which they were fairly numerous and where they equaled or exceeded the latter in numbers. The breeding places in one of these areas centered at a pond supplied with flowing water from several springs and full of aquatic vegetation. Larvæ of both kinds were taken in the pond and its overflow ditch, and in various small creeks, canals, and springs in the surrounding area. At another place numerous *filipinæ* larvæ in nearly "pure culture" were taken at the edge of a stream flowing from a large spring. Part of these were collected in a growth of *Pistia* and part in a growth of water morning-glory, *Ipomoea* sp. In other instances the larvæ have been taken in pure culture in a growth of water hyacinth and along the grassy margin of canals. (See also footnote 11.)

My present records of the occurrence of *A. mangyanus* are not extensive but the species is evidently quite widely distributed on Luzon and the larvæ have been taken in considerable numbers in certain localities. For the most part they have been found in swiftly flowing streams, free of aquatic vegetation, close to the mountains or in forested areas. Although usually mixed with *minimus* larvæ, *mangyanus* has been the predominating form in a majority of collections in which it occurs at all. Differences in temperature or in organic composition of the water may

account for its slightly different distribution. Like *minimus*, the most favorable collecting place is among exposed tree-roots in under-cut banks. As a mountain or forest stream breeder, however, *mangyanus* has not as yet been taken except at low altitudes.[3]

Anopheles minimus is found throughout the foot hills and rolling lands generally and, as indicated, tends to overlap each of the others. I also have a number of records in which all three species were collected in the same or nearby streams, so their breeding limits are not sharply drawn.

From the observations made it may be concluded that, while the species have preferences for somewhat different types of breeding-places, they are frequently more or less closely associated under natural conditions.

SPECIFIC STATUS

The occurrence of the three species in the same localities undoubtedly throws some light on the specific status of all the members of this subgroup, a question on which various opinions have been expressed.

The fact that they maintain distinctive characteristics although associated in nature is very convincing evidence that interbreeding does not normally occur and for this reason the three should be regarded as distinct species, rather than varieties of one. In view of this it is of interest to note that the anatomical differences are of about the same order as or even less distinctive than those separating *funestus*, *minimus* (type form), and *aconitus*, to mention only those that I have compared, so the evidence also tends very strongly to confirm the opinion held by Christophers, Edwards, and others in regard to the specific differentiation of these forms.

COMPARATIVE MATERIAL

In connection with the study of the Philippine species of this group I have fortunately been able to obtain, either from the type or other representative locality, a few specimens of several of the related species. This material consists of adults and larvæ of *Anopheles minimus* from Hong Kong and Kow-

[3] Several collections in mountain streams have shown *mangyanus* associated with *Anopheles insulaeflorum* Swell., a species not hitherto identified from the Philippines.

loon, China, *Anopheles aconitus* from Java, and *Anopheles funestus* from Sierra Leone and Nigeria, Africa.[4]

From the comparative study it has developed that fairly distinct and constant differences between several of the species are to be found in the characters of the male genitalia, particularly in the hairs of the claspettes and also, in *A. funestus*, in the size of the leaflets of the mesosome. These differences have not, I believe, been previously recorded and in fact the genitalia have been generally considered as entirely similar.

OTHER ORIENTAL SPECIES

The two Indian representatives of the subgroup, *Anopheles listoni* Liston and *Anopheles varuna* Iyengar, have not been available for comparison, but the published descriptions indicate that they are sufficiently distinct from the Philippine species.

Anophelės formosaensis I Tsuzuki (from Formosa) is considered by Yamada (1925) to be synonymous with *A. minimus* and to differ from var. *flavirostris*. *Anopheles cohæsa* Dönitz (Java) was proposed as a substitute name for Tsuzuki's *formosaensis I*, and *Anopheles merak* Mangkoewinoto (also from Java) was thought by its author to be probably identical with Dönitz' *cohæsa*. These have been included by Christophers among the synonyms of *minimus*, and the possible relation of the Javan form to one of the Philippine forms cannot be definitely determined from the published descriptions.

DESCRIPTION AND DISCUSSION OF SPECIES

The species considered here belong to the subgenus *Myzomyia* and group *Myzomyia* as defined by Christophers (1924). I have referred to the species as members of the "*funestus-minimus* subgroup." Christophers and Puri (1931) have suggested the term "*funestus* series."

[4] For their kindness in sending me this material, I am very much indebted to Dr. R. Soesilo for the *aconitus* specimens, to Dr. R. M. Gordon for those from Sierra Leone, and to Dr. M. A. Barber for the Nigerian specimens, which were obtained at Lagos, Ibadan, and Abeokuta, the latter having been sent to Doctor Barber by Doctor Anderson. The Chinese specimens were personally collected in 1929, with the kind assistance of the Medical and Sanitary Services at Hong Kong.

ANOPHELES MINIMUS var. FLAVIROSTRIS Ludlow.

Pyretophorus minimus GILES (not Theobald), 1904b.
Myzomyia funesta LUDLOW (not Giles), 1905 to 1914, in part.
Myzomyia flavirostris LUDLOW, 1914a. (See also 1914b.)
Anopheles christophersi EDWARDS (in part, not Theobald), 1914.
Anopheles (*Myzomyia*) *christophersi* LUDLOW (in part, not Theobald), 1915.
Anopheles minimus EDWARDS (not Theobald), 1915.
A. minimus var. *aconitus* CHRISTOPHERS (not Dönitz), 1916.
A. (*Myzomyia*) *minimus* CHRISTOPHERS (in part, not Theobald), 1924.
M. minima var. *flavirostris* YAMADA, 1925.
Anopheles minimus BAISAS, 1927. (Description of larva.)
Anopheles funestus MANALANG (in part, not Giles), 1930 *et seq.*

The type locality of *Myzomyia flavirostris* is Camp Wilhelm, Tayabas Province, Luzon, and the type specimens (four females) are now in the United States National Museum.

The species was described as new because of the flavescent appearance of the proboscis, but shortly after publishing the description, the author placed her species as well as Banks' *M. mangyana* and *M. febrifera* in synonymy with *Anopheles christophersi*. In an editorial footnote to the same article (quoting Edwards) *christophersi* is made a synonym of *A. minimus*.

Many of the recent Philippine records for *minimus* apply to this form, but the identifications have undoubtedly included at various times the two other species now recognized.

The accompanying description of var. *flavirostris*, except where otherwise noted, is based on larvæ and reared adults from Luzon.

I have found this form to be abundant also on Negros and Mindanao and, on the latter island, collected it at elevations of about 2,000 feet (Bukidnon and Lanao Provinces). Several dozen adults from these two islands were reared from lots in which only *flavirostris* type of larvæ were identified (not, however, from individually isolated specimens with a mount of the corresponding larval skin as in the case of the Luzon series). A certain amount of variation in the markings of female specimens from the three sources may be noted in Tables 1 and 2, especially the absence of continuous dark scaling on vein 5.1 in the Mindanao specimens.

Female.—Palpi (Plate 2, fig. 2) with two broad apical pale bands of nearly equal width and normally about twice the width of the intervening black band. Proboscis (Plate 2, fig.

8) with distinct pale scaling on the apical half in nearly all specimens and in many cases resembles very closely the appearance of the proboscis in several specimens of *aconitus* at hand. The typical marking consists of a fairly definite patch of yellowish scales ventrally and laterally beginning near the middle or the apical third and narrowing toward the tip, usually separated from the labella by darker scales. In a few specimens the pale scaling extends around the proboscis, and only 4 specimens of 113 in which the proboscis was examined (59 from Luzon, 15 from Negros, and 39 from Mindanao) fail to show more than an indefinite paling toward the tip such as may be seen in other species. The marking is therefore quite characteristic of the variety but the pale scaling may be missed if the proboscis is not properly lighted when examined.

Wings.—Basal third of wing costa (Plate 1, fig. 1) entirely dark in 23 per cent of the Luzon series, a few white scales indicating the presector[5] white spot in 27 per cent and a complete presector spot in 50 per cent, one specimen only with an additional small spot above the humeral crossvein. Another specimen from Negros, not from an identified larva, also has a small humeral spot.

Subcostal and subapical costal white spots much reduced, each averaging about one-third the length of the subapical dark area; subapical dark spot on vein 1 occasionally with a few white scales (5 to 70 specimens); veins 2.1 and 2.2 without central white spots; vein 3 on an average with more than half of the central portion white (one specimen with the vein continuously dark scaled); vein 5.1 usually with a central white area, although about one-fourth of the Luzon specimens are entirely dark scaled (except at the tip and crossvein) as in *funestus*. None of the Mindanao specimens, however, show this condition (Table 1). Vein 6 either with or without a pale spot interrupting the basal half of the dark area but without a pale interruption on the apical half such as occurs in some specimens of *filipinæ;* wing fringe dark opposite the sixth vein in all specimens except one; white fringe spots opposite all other veins and continuous between veins 2.2 and 3.

Male.—A few pale scales above the humeral crossvein and a slight fringe spot at the end of vein 6 are occasionally noted

[5] The terminology of the wing spots as employed here has been given in a previous article (King, 1932, fig. 1).

in male specimens, while the proboscis is not usually pale scaled as in the female. The antennal club has a narrow basal white band, a wide white area centrally and a white tip.

TABLE 1.—*Variations in female wing spots in several species of Anopheles of the funestus-minimus series.*

	Anopheles minimus var. *flavirostris.*			*Anopheles minimus.*	*Anopheles funestus.*		*Anopheles mangyanus.*	*Anopheles filipinae.*
	Luzon.	Negros.	Mindanao.	Hong Kong.	Sierra Leone.	Nigeria.		
Number of specimens examined	70	15	40	4	6	14	46	38
White spots on basal third of costa:	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
No spots	23	33	20	0	0	54	0	0
One [a]	76	60	80	100	100	46	0	45
Two [b]	1	[c] 7	0	0	0	0	100	55
Accessory sector and sector spots on vein 1:								
Continuous	36	20	48	75	100	79	9	36
Separated [d]	64	80	52	25	0	21	91	64
Central white spot on vein 5.1:								
Present	73	87	100	50	0	0	86	84
Absent	27	13	0	50	100	100	14	16
Dark spots on vein 6:								
One	29	53	5	0	50	7	9	8
Two	71	47	95	100	50	93	91	65
Three	0	0	0	0	0	0	0	27
Fringe spot at vein 6:								
Present	1	0	0	0	0	0	5	73
Absent	99	100	100	100	100	100	95	27

PROPORTION OF CENTRAL WHITE AREAS ON VEINS 3 AND 5.1 TO TOTAL LENGTH OF VEIN (MEASURED TO CROSSVEIN).

Vein 3, average	[e] 0.54	0.63	0.69	0.60	0.27	0.35	0.66	0.63
Vein 5.1, average [f]	0.29	0.30	0.42	0.44	0.0	0.0	0.32	0.28

[a] The presector white spot. This spot was incomplete or represented by only one or two scales in about half (55 per cent) of the *flavirostris* specimens listed as having one spot.

[b] Humeral and presector white spots.

[c] One specimen.

[d] Includes those with only one or two dark scales intervening.

[e] Does not include one specimen with vein 3 continuously dark scaled.

[f] Does not include specimens in which the central white spot is lacking.

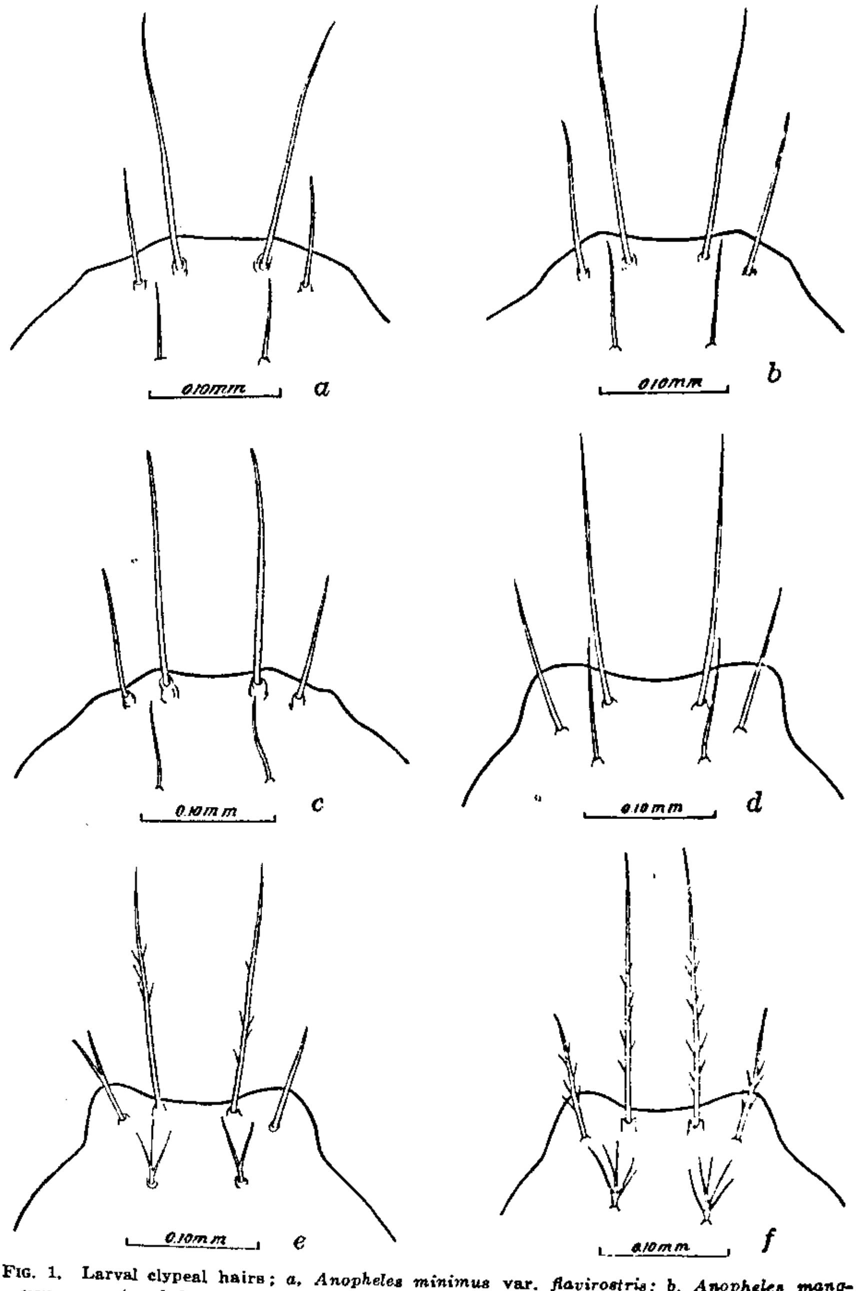

FIG. 1. Larval clypeal hairs; *a, Anopheles minimus* var. *flavirostris; b, Anopheles mangyanus; c, Anopheles minimus* (type form); *d, Anopheles funestus; e, Anopheles filipinæ; f, Anopheles aconitus.*

Male hypopygium.—Mesosome (fig. 8, *a*) with four or five pairs of leaflets, the first one wide and flat and serrated on one side nearly to the tip; other leaflets shorter and narrower and one or two of them also serrated. Average length of the longest leaflet, 36 μ.

TABLE 2.—*Comparative widths of the distal palpal bands of the female in several species of Anopheles.*

	Number measured.	Apical white band (average proportion).	Subapical dark band (average proportion).	Subapical white band (average proportion).	Variation in proportion of subapical white.
Anopheles minimus var. *flavirostris:*					
Luzon	18	0.40	0.19	0.41	0.33–0.48
Negros	12	0.40	0.20	0.40	0.33–0.47
Mindanao	22	0.38	0.24	0.38	0.33–0.43
Anopheles minimus: Hong Kong	5	0.40	0.24	0.37	0.28–0.43
Anopheles funestus:					
Sierra Leone	5	0.32	0.42	0.26	0.23–0.30
Nigeria	16	0.29	0.47	0.24	0.17–0.34
Anopheles mangyanus	[a] 40	0.41	0.23	0.36	0.26–0.44
Anopheles filipinæ	34	0.48	0.25	0.27	0.18–0.37

[a] Two specimens in which the subapical dark band is lacking are not included.

Claspette (harpago) (fig. 7, *a*) with three long hairs, consisting of an inner and outer hair of nearly equal length, and a longer and stouter apical hair. The outer hair is about the same length as the club or slightly shorter, but arises farther forward on the lobe and extends beyond the tip of the club. The inner hair was present on both sides in all specimens except two and in each of these cases the hairs on one side had plainly been broken off during dissection since the small basal cone could be made out (in addition to the circular "root spot," bearing a minute hair, that is found in all specimens). Duplication of any one of the claspette hairs may occur and the club may also be double or have a separate leaflet.

The parabasal spines and the shape of the leaflets of the mesosome are quite similar in all the species of the subgroup that have been examined. Certain differences, to be noted under each form, occur in the hairs of the claspettes and in the length of the mesosomal leaflets (Table 3).

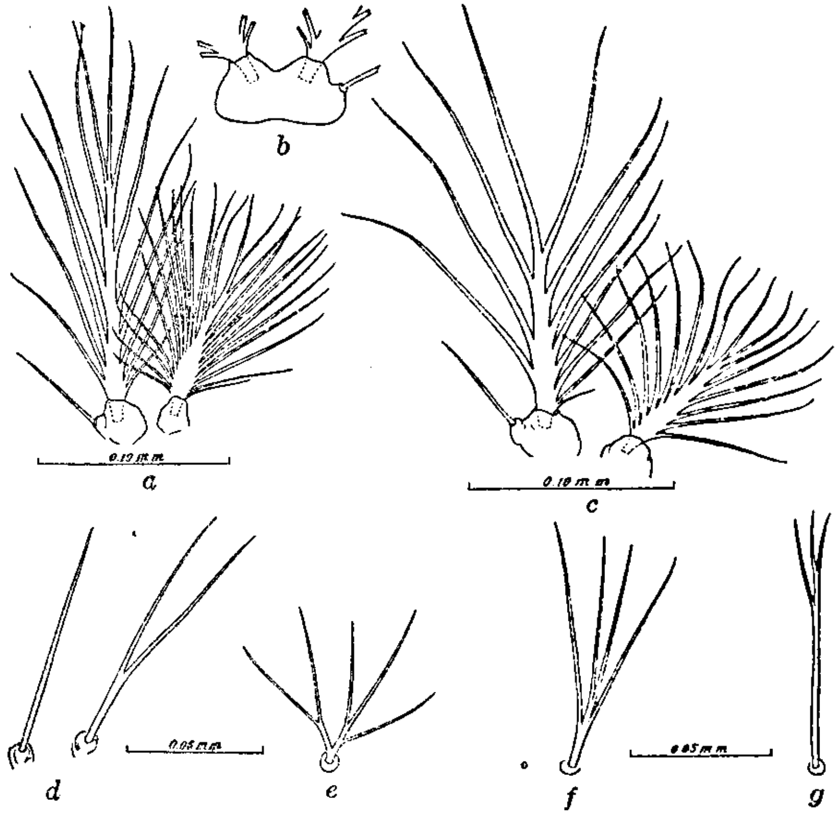

FIG. 2. *a*, submedian prothoracic hairs of *Anopheles minimus* var. flavirostris; *b*, bases of the submedian prothoracic hairs of *Anopheles funestus*, showing the type of fusion in this species; *c*, submedian prothoracic hairs of *Anopheles filipinæ*; *d*, inner (left) and outer occipital hairs of *Anopheles funestus*; *e*, inner occipital hair of *Anopheles minimus* var. *flavirostris*; *f*, antepalmate hair from abdominal segment II of *Anopheles minimus* var. *flavirostris*; *g*, the same of *Anopheles filipinæ*.

Larva.—Inner clypeal hairs (fig. 1, *a*) long and simple; outer hairs stout and about half the length of the inner; posterior hairs slender and seldom reach beyond the base of the inner; outer and posterior clypeal hairs occasionally forked toward the tip. Inner occipital hairs (fig. 2, *e*) usually with more than three branches and in typical specimens the hair is divided near the base with secondary branches arising from each stem. Inner submedian prothoracic hairs (fig. 2, *a*) with a stout stem and numerous, symmetrically arranged branches, averaging 24 branches each and seldom with less than 21; bases of the submedian hairs usually separated, but are narrowly fused on one

TABLE 3.—*Measurements of the mesosome, the mesosomal leaflets, and the claspette spines of the male hypopygium in several species of Anopheles.*

	Anopheles minimus var. *flavirostris.*	*Anopheles minimus* (Hong Kong).	*Anopheles funestus* (Africa).	*Anopheles mangyanus.*	*Anopheles filipinæ.*	"*Anopheles febrifer.*" [a]
Number of specimens	16	5	6	17	10	6
Mesosome:						
Number measured	12	4	4	15	6	4
Average length[b] ... μ	83	91	106	90	86	98
Variation ... μ	80–94	87–94	103–108	82–99	75–94	92–106
Long leaflets of mesosome:						
Number measured	27	10	12	33	18	10
Average length ... μ	36	36	49	36	30	39
Variation ... μ	34–38	34–38	45–53	34–41	28–33	34–42
Inner claspette hair:						
Number measured	26	4	2	4	0	0
Average length ... μ	52	36	29	42	----------	----------
Variation ... μ	38–68	----------	----------	----------	----------	----------
Apical claspette hair:						
Number measured	25	10	12	33	18	12
Average length ... μ	78	79	69	75	72	83
Variation ... μ	68–85	71–85	61–78	63–85	70–88	75–87
Outer claspette hair:						
Number measured	31	12	12	35	18	12
Average length ... μ	51	52	30	50	47	54
Variation ... μ	42–56	45–56	26–38	35–56	40–56	49–59
Club of claspette:						
Number	32	10	12	34	17	12
Average length ... μ	58	61	65	54	57	59
Variation ... μ	49–71	56–63	58–71	42–61	47–66	51–66

[a] M. A. Barber's specimens having humeral costal spots and without an inner hair on the claspette. Specimens from Canlubang, Laguna Province, 1914.

[b] The measurements were made at a magnification of × 425, and are given in microns.

or both sides in about 25 per cent of the specimens and occasionally broadly fused, as in *funestus;* thoracic palmate hairs (fig. 3, *a*) not extended into a slender filament; leaflets of abdominal segments with comparatively short filaments, ratio of filament to blade (Table 5), 0.54; antepalmate hairs (hair 2) on abdominal segments 2, 3, and 7 branched near the base (fig. 2, *f*), usually from three to five times, those on segment 3 being somewhat more variable than the others in regard to the point of branching, but the first branches arise from the basal third.

Tergal plates.—The plate on segment 1 (fig. 4, *a*) is narrow and more or less rectangular in shape except for a projection in front; the main plate on segment 2 is invariably notched or concave posteriorly (as noted by Manalang) and the small me-

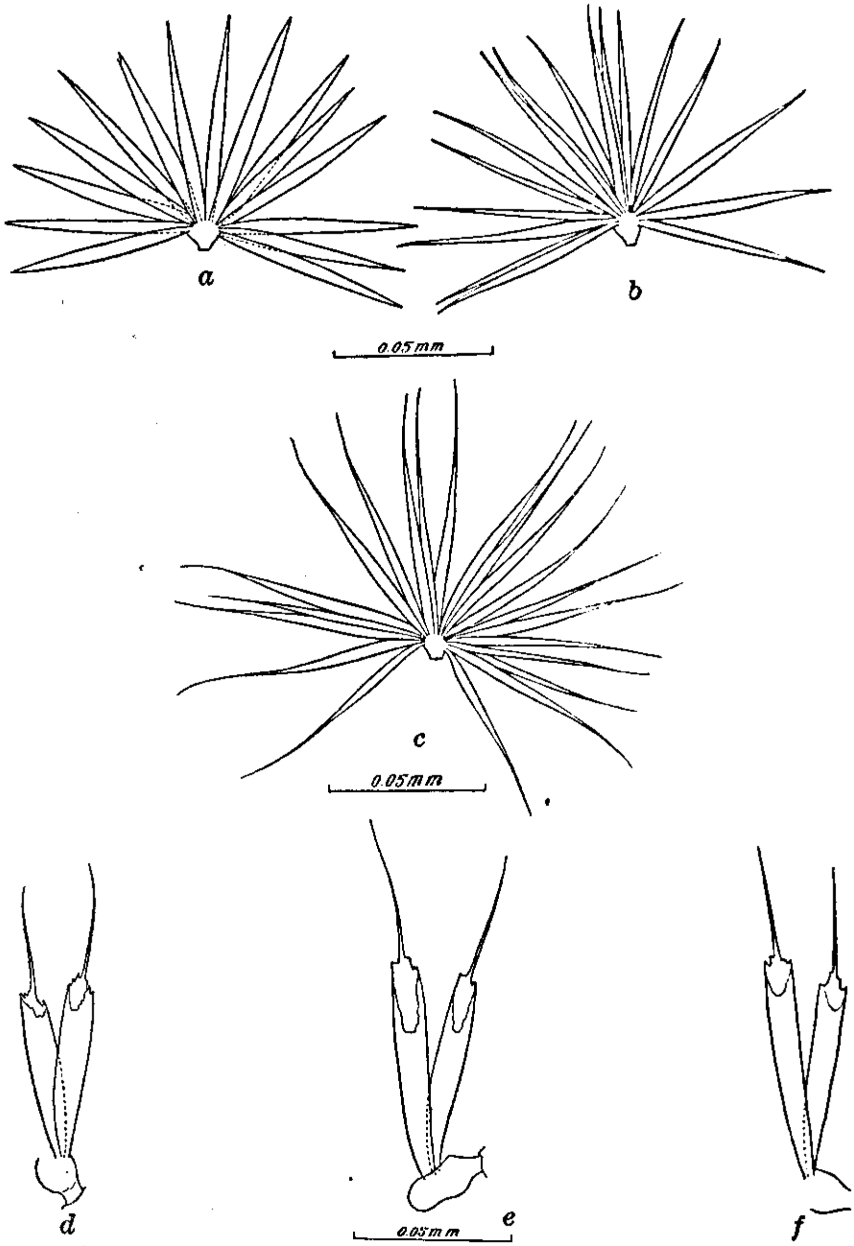

FIG. 3. Thoracic palmate hairs (*a* to *c*) and leaflets of abdominal palmates from segment IV (*d* to *f*); *a*, *Anopheles minimus* var. *flavirostris*; *b*, *Anopheles filipinæ*; *c*, *Anopheles mangyanus*; *d*, *Anopheles minimus* var. *flavirostris*; *e*, *Anopheles mangyanus*; *f*, *Anopheles filipinæ*.

dian plate or a detached portion of the main plate lies in this concavity. The first two plates are similar to those of *mangyanus*. The remainder of the plates, except on segment 8, have a decidedly convex posterior margin as a rule and taper to more or less of a point at each end. This is especially noticeable on segments 3, 4, and 5, and in typical specimens the shape is decidedly different from that of *filipinæ, mangyanus*, or *funestus*. In some specimens the plates on segments 3 to 6 are almost diamond-shaped and some have the small median plate detached on segment 3 or 4. The small oval submedian or posterior plates are not well chitinized as a rule, but in cleared specimens they are frequently visible, especially toward the posterior end, or they may be indicated by an unchitinized scar. The minute anterior tergal hairs, hair "O" of Puri, usually do not arise from the main plate but their location is subject to some variation. In the majority of specimens they are well separated (at least their own length away); in others they may arise from the very edge of or sometimes definitely on the plate itself. These hairs are usually simple.

The dorsal surface of the larva is mottled with a dense subdermal pigmentation that extends well forward under the tergal plates on the abdominal segments. Small spots of opaque white are scattered through the dark pigmentation, especially on the thorax. On the ventral side of the abdominal segments are small central pigmented spots. The general naked-eye appearance of the larva is very dark brown or black and differs in this respect from most of the *filipinæ* larvæ.

In living or freshly killed larvæ and especially in those preserved in formalin the pigmentation is frequently so dense that the tergal plates are obscured and the posterior margin difficult to make out. For study purposes it is helpful to clear the specimens in caustic soda before mounting.

In the cast larval skins or in cleared larval specimens, minute scattered spines (the vestitural setæ) are barely visible on the ventral surface of the abdominal segments, but never produce prominent dark bands as observed in *funestus* larvæ.

ANOPHELES MINIMUS Theobald, 1901.

Female.—Definite pale scaling of the proboscis is not apparent in the ten female specimens at hand from Hong Kong and was not noted by Yamada (1925) in those he examined. The frequency and extent of the pale scaling in the Philippine form is therefore of some significance.

TABLE 4.—*Comparative branching of larval hairs in several species of Anopheles.*

	Anopheles minimus var. *flavirostris* (Luzon).		*Anopheles minimus* (Hong Kong).		*Anopheles funestus* (Africa).		*Anopheles mangyanus* (Luzon).		*Anopheles filipinæ* (Luzon).		*Anopheles aconitus* (Java).	
	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.	Number.	Per cent.
Larval specimens recorded [a]	111	-------	8	-------	21	-------	79	-------	102	-------	5	-------
Inner clypeal hairs:												
Simple	202	100	14	100	40	100	155	[b]99.4	1	0.5	0	-------
Frayed	0	-------	0	-------	0	-------	0	-------	189	99+	10	100
Outer clypeal hairs:												
Simple	208	99	16	100	42	100	154	100	155	79	0	-------
Two to 4 branched	2	1	0	-------	0	-------	0	-------	40	21	0	-------
Frayed	0	-------	-------	-------	0	-------	0	-------	0	-------	10	100
Postclypeal hairs:												
Simple	265	99	16	100	36	100	137	97	15	7	0	-------
Two to 5 branched	[c]3	1	0	-------	0	-------	[c]4	3	192	93	10	100
Inner occipital hair:												
Variation (in number of branches)	2-12	-------	4-8	-------	1	-------	2-9	-------	2-8	-------	4-7	-------
Average	5.2	-------	5.6	-------	1	-------	5.0	-------	3.3	-------	5.0	-------
Usual	3-7	94	-------	-------	1	100	4-6	71	2-4	92	4-5	75
Outer occipital hair:												
Variation	2-12	-------	4-9	-------	2-4	-------	3-10	-------	2-8	-------	5-9	-------
Average	4.8	-------	5.9	-------	2.3	-------	6.3	-------	3.8	-------	6.1	-------
Usual	2-6	95	-------	-------	2-3	97	5-7	76	2-5	93	5-6	67
Submedian prothoracic hairs:												
Inner—												
Variation	18-30	-------	21-31	-------	16-23	-------	15-26	-------	12-22	-------	10-21	-------
Average	24.2	-------	25.8	-------	19.1	-------	20.9	-------	16.8	-------	16.9	-------
Usual	22 plus	89	21 plus	100	17-21	94	18-23	91	14-20	97	-------	-------

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Middle—												
Variation	11-20	....	14-20	....	12-17	....	12-20	....	10-18	....	10-13	....
Average	14.1	....	16.9	....	14.6	....	15.2	....	13.2	....	11.6	....
Antepalmate hairs:												
Segment II—												
Variation	3-7	....	4-6	....	3-6	....	2-5	....	2-6	....	3-5	....
Average	4.6	....	4.8	....	4.7	....	3.5	....	3.3	....	4.1	....
Usual	4-5	86	....	....	5	35	3-4	90	3-4	81	....	....
Segment III—												
Variation	2-6	....	2-4	....	3-5	....	1-4	....	1-4	....	2-3	....
Usual	3-4	93	3-4	88	4-3	90	3-2	95	3-2	89	3	51
Segments IV to VI—												
Variation	1-2	....	[illegible]	....	1-2	....	1	....	1-2	....	1	....
Usual	1	99.5	1	100	1	99	1	100	1	99.8	1	100
Segment VII—												
Variation	3-5	....	3-5	....	2-5	....	1-2	....	2-5	....	3-4	....
Usual	3-4	92	3	63	4	56	1	93	4-3	82	....	....
Lateral hairs:												
Segments IV to VI—												
Variation	2-4	....	2-3	....	2-5	....	2-4	....	2-5	....	3	....
Usual	3	91	3	97	3	85	3	65	2	95	3	100

[a] Both hairs in each pair were counted so far as possible, except that in the case of *flavirostris* and *filipinæ* only one of the inner and the middle submedian prothoracic hairs was recorded.

[b] One inner clypeal hair forked at tip.

[c] Hairs forked.

TABLE 5.—*Measurements of palmate leaflets in three Philippine species of Anopheles.*

	Number measured.[a]	Blade.	Filament.	Total length.	Ratio of filament to blade.
		mm.	*mm.*	*mm.*	
Anopheles minimus var. *flavirostis*	78	0.064	0.034	0.098	0.54
Anopheles mangyanus	126	0.065	0.057	0.122	0.88
Anopheles filipinæ	121	0.062	0.039	0.101	0.63

[a] Two leaflets measured per specimen, one each from segments IV and V.

Christophers and Puri (1931) state that some of the Indian *minimus* have a small pale tache on the ventral side of the pro-

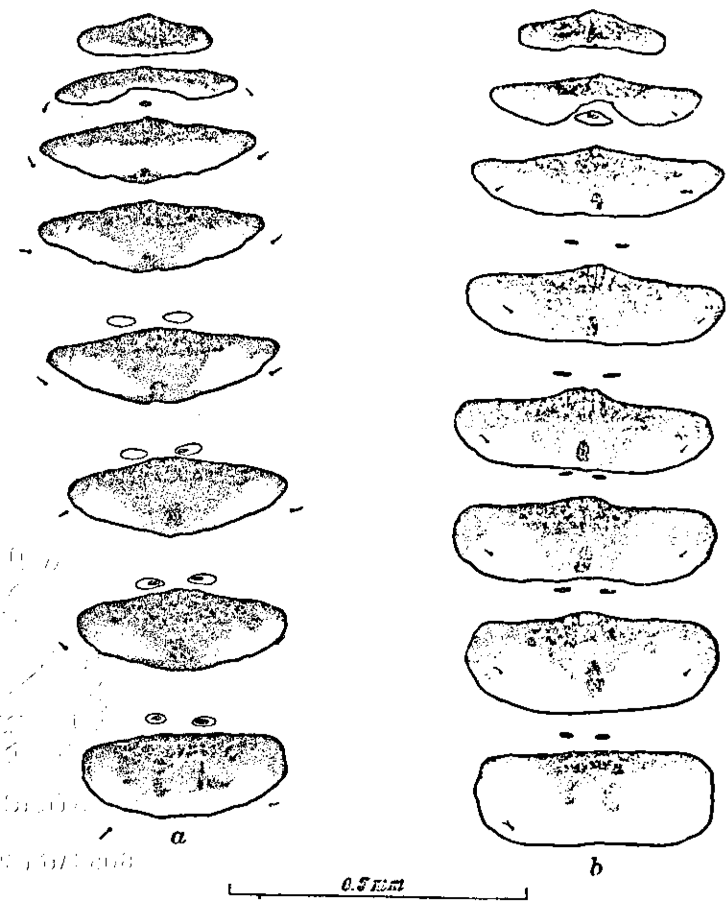

FIG. 4. Tergal plates; *a*, *Anopheles minimus* var. *flavirostris*; *b*, *Anopheles mangyanus*.

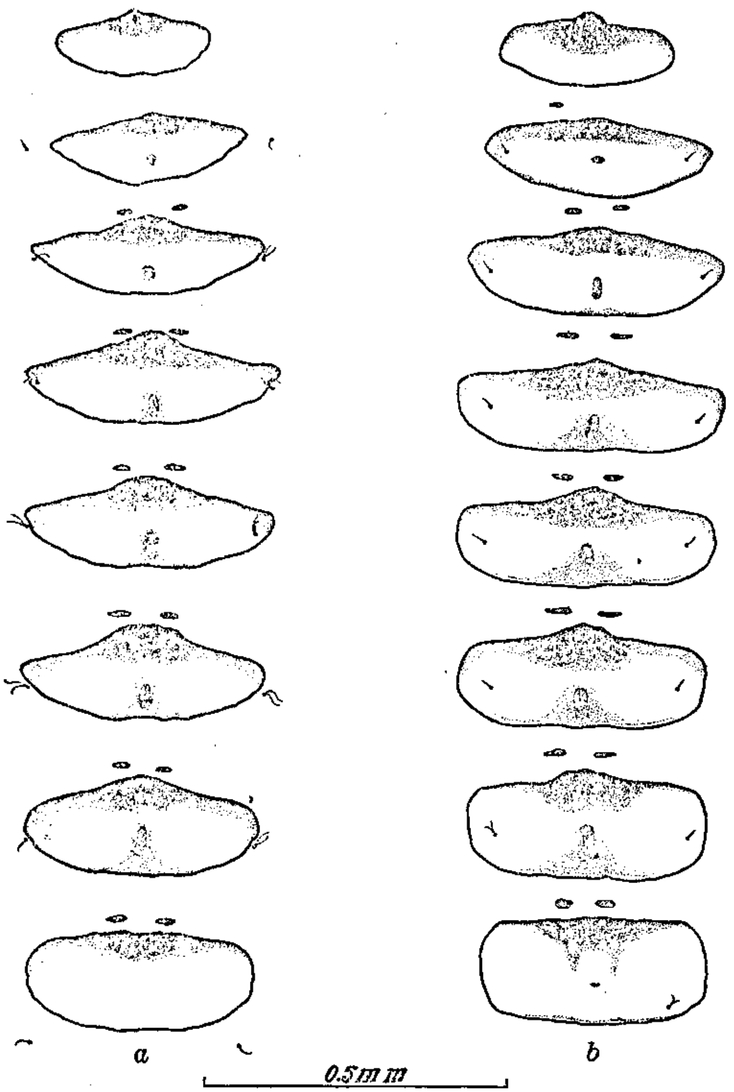

FIG. 5. Tergal plates; *a*, *Anopheles aconitus*; *b*, *Anopheles filipinæ*.

boscis but the marking is apparently much less constant and distinct in that form than in var. *flavirostris*.

These authors also state that a white interruption at the base of the wing costa occurs very constantly in their series and this may be compared with the entirely dark-scaled base in 23 per cent of the Luzon specimens.

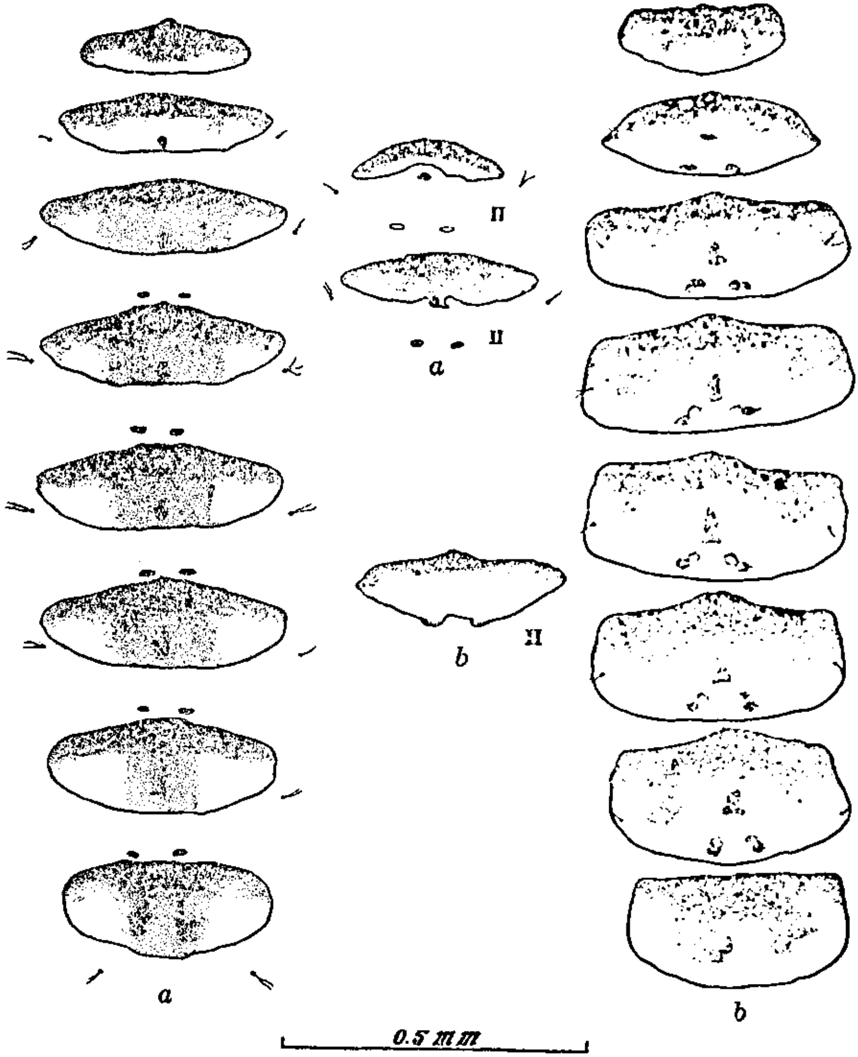

FIG. 6. Tergal plates and examples of variations in the shape of plate II; *a*, *Anopheles minimus* (type form); *b*, *Anopheles funestus*.

Male hypopygium.—The development of inner claspette hairs shows a decided tendency to differ in the two forms. In var. *flavirostris*, as previously stated, a long inner hair is present in each of seventeen specimens while of five Hong Kong males the hair is absent in two (fig. 7, *b*), a short hair is present on one side in one (fig. 7, *c*), a fairly long hair on one side in another, and short hairs are present on both sides in the fifth.

None of the five, therefore, is exactly similar to the normal condition of the claspette of the Philippine specimens.

Larva.—So far as observed, the larval characters are quite similar to those of var. *flavirostris* with the exception of the shape of the second tergal plate, the branching of the anterior tergal hairs, and possibly in the increased amount of chitinization of the small submedian plates, including those on the metathorax.

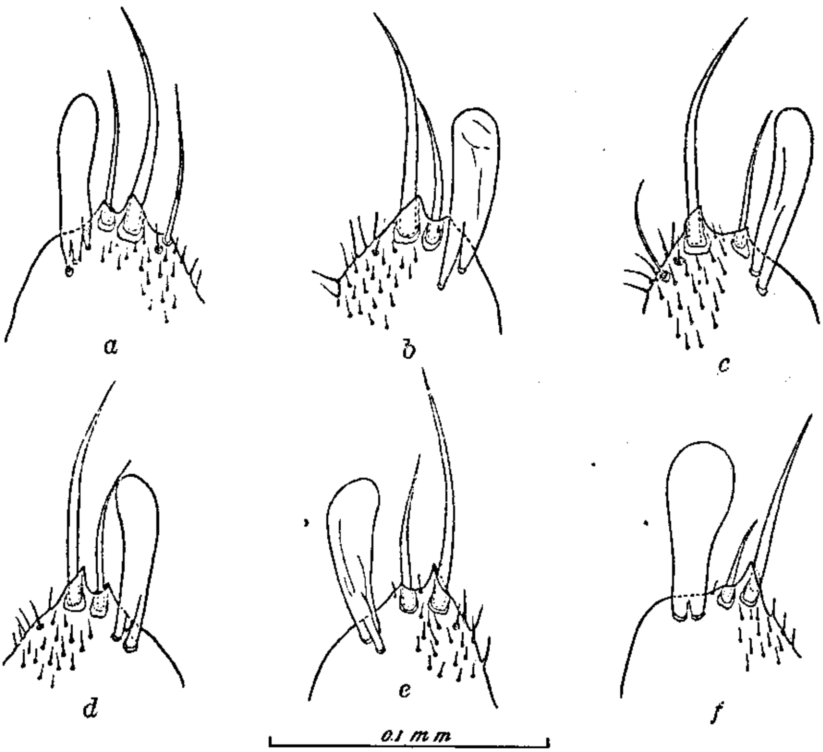

FIG. 7. Claspette hairs of male hypopygium; *a*, *Anopheles minimus* var. *flavirostris*; *b* and *c*, *Anopheles minimus* (type form), the second figure showing a short inner hair; *d*, *Anopheles mangyanus*; *e*, *Anopheles filipinæ*; *f*, *Anopheles funestus*.

The second tergal plates are variable in shape (see fig. 6, *a*), two specimens having the anterior plate crescent-shaped and the median plate detached as in *flavirostris*, two with the anterior plate only slightly notched but the median plate also detached, and three with the median plate fused with the main plate. In two of the last three the posterior border is straight and unbroken, a condition that has not been observed in any specimens of the Philippine form.

The anterior tergal hairs do not ordinarily arise from the plate in either form but they are usually bifid in the Hong Kong specimens, instead of simple, and are sometimes 3- or 4-branched.

While the two forms are plainly more closely related than are other members of the group, the differences are sufficient to justify the rank of geographical subspecies.

ANOPHELES FUNESTUS Giles, 1900.

The specimens examined from Sierra Leone and Nigeria show the characteristics as given by various authors and these may be briefly summarized as follows:

Female.—Palpi (Plate 2, fig. 4) with a broad subapical black band, as wide as or wider than either white band; basal third of wing costa with or without one white interruption; vein 3 about two-thirds dark; vein 5.1 dark except for small white spots at the tip and crossvein; fringe dark opposite vein 6. (The wing is illustrated in Plate 2, fig. 1).

Larva.—Clypeal hairs (text fig. 1, *d*) all simple; inner occipital hair simple (instead of branched as in all other members of the group) and outer occipital usually only 2- or 3-branched (fig. 2, *d*); small submedian tergal plates fused with the main plates (instead of being separated); anterior tergal hairs (hair O) arising from the large plate.

To these characters I can add that the posterior clypeal hairs are placed farther forward than usual and overlap the base of the inner anterior pair by one-half to two-thirds their own length. The inner anterior thoracic hairs tend to be slightly less branched than those of *minimus* and var. *flavirostris* and the bases of the inner and middle hairs are broadly fused (fig. 2, *b*). The tergal plates (fig. 6, *b*) are comparatively very large and differ in shape from those of the two forms mentioned.

A striking larval difference is the spinose condition of the ventral surface of the abdominal segments. This consists of numerous rows (15 to 20) of short dark spines which produce well marked bands on the central segments. The rows are transverse and the banding is especially evident in cast skins or cleared larvæ, but the setæ can also be made out readily enough in normally dense specimens.

Male hypopygium.—Outer claspette hair (see fig. 7, *f*), short and stout instead of long and slender; club unusually large and nearly as long as the apical hair; inner hair lacking in

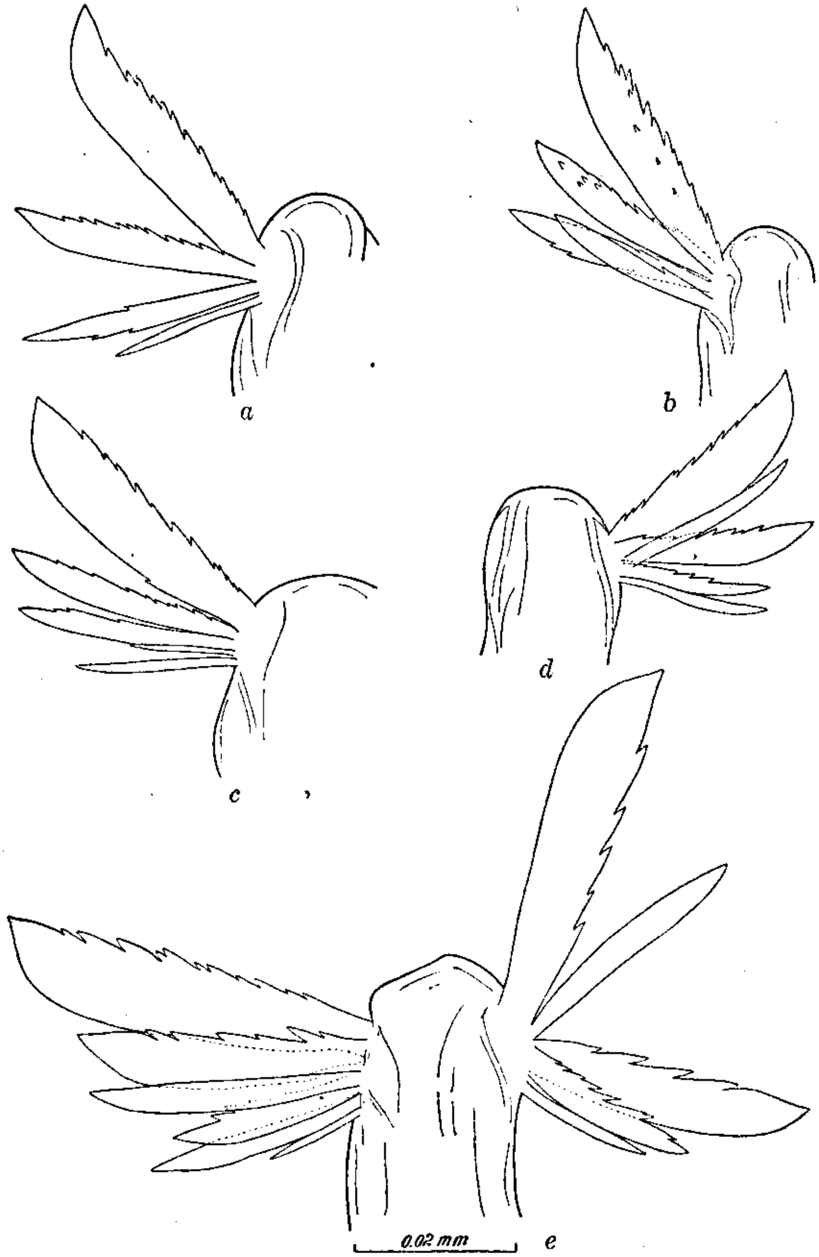

FIG. 8. Mesosomal leaflets; *a*, *Anopheles minimus* var. *flavirostris*; *b*, *Anopheles minimus* (type form); *c*, *Anopheles mangyanus*; *d*, *Anopheles filipinæ*; *e*, *Anopheles funestus*.

five specimens but short hairs on both sides are present on the sixth.

The leaflets of the mesosome (fig. 8, *e*), and also the mesosome itself, are decidedly longer than in the other members of the group, the differences being noticeable even under the low powers of the dissecting microscope. The average length of the longest leaflet is 49 μ, compared with averages of 30 to 39 μ for any of the other species examined.

The larval and genitalic characters of *funestus* are therefore distinctive in several respects.

ANOPHELES MANGYANUS Banks.

? *Pyretophorus pitchfordi*[a] GILES, 1904*b* (not Giles, 1904*a*).
Myzomyia mangyana BANKS, 1907.
Anopheles christophersi EDWARDS (in part, not Theobald), 1914.
Myzomyia febrifera BANKS, 1914.
Anopheles febrifer WALKER and BARBER (for the most part), 1914.
Anopheles (Myzomyia) christophersi LUDLOW (in part, not Theobald), 1915.
Anopheles minimus CHRISTOPHERS (in part, not Theobald), 1916.
Probably *Anopheles minimus* and *Anopheles funestus* (in part) and possibly *Anopheles aconitus* var. *filipinæ* (in part) of Philippine authors.

The specimens of *M. mangyana* in the Bureau of Science collection (all females) consist of the type and two cotypes (so labeled), another specimen and a half dozen empty pins all bearing the same accession number (3290), and three specimens, evidently from the empty pins, which were found unmounted in the same box.

One of the unmounted specimens is in very poor condition but the other six, while in poor condition also, all have distinct humeral and presector white spots. Two of the specimens (both cotypes) still retain their palpi and in one of these the three apical bands are of about equal width; the other has both white bands wider than the dark. The subcostal and subapical costal white spots in all six specimens are from one-half to three-fourths the length of the subapical dark spot (resembling many

[a] Identified from specimens received from Camp Stotsenburg, Pamp., (Luzon) P. I. and probably of this form or *filipinæ*. *Pyretophorus minimus* was also recorded from the same collection so the identification could not be referred to var. *flavirostris*.

of my *mangyanus* specimens). Fringe spots cannot be made out at the end of vein 6, but the fringe is either faded or rubbed in all of the material. Banks' description indicates that they were not present originally. The apical half of vein 6 is without a white interruption in three specimens (undetermined in the others).

Mr. McGregor, who collected the specimens, told me that they were taken at a camp on Rio Baco about six kilometers inland from the north coast of Mindoro. Except for a small area that was being cleared for cultivation at the camp, all of the surrounding territory was heavily wooded.

The evidence as to the identity of this species is suggestive though not final and if it should prove to be the same as *filipinæ*, the form to which the name is here assigned would become *Anopheles febriferus*.

As previously mentioned, the important development in connection with the latter name is the probability that much, perhaps most, of the material for which experimental results were reported by Walker and Barber in 1914 as *Anopheles febrifer* was not *A. minimus* as has always been supposed.

The available evidence applying to the relationship of *M. febrifera* and to the identification of the Walker and Barber material may be cited as follows:

The type female of *M. febrifera* has a distinct white spot on the wing costa above the humeral crossvein; the subapical white palpal bands are only slightly wider than the subapical dark band and the proboscis is not pale; the presence or absence of a fringe spot at the end of vein 6 is doubtful since the fringe scales are quite faded. This specimen might or might not, therefore, be *filipinæ* but is almost certainly not *flavirostris*.

The Bureau of Science collection still contains about two dozen specimens labeled with various cage numbers and initialed by Doctor Barber, showing that they were from experimental lots. There are also a few from Canlubang, Capatagan, and Cristobal Rivers, small streams near the sugar central of Canlubang where the experimental work was conducted, and still other specimens, from Barber's collections, from various localities in the same province (Laguna).

Although these specimens are now practically all in poor condition, the scaling at the base of the wing can still be made out

on most of them and the distribution of the material in regard to the basal spots is as follows:

Those having a humeral white spot consist of—

Type female and male[7] labeled "Cage 56 *M. funesta* 4-2-14 M.A.B., E.L.W." and a second label "Acc. No. 18015 Bu. Sci. P. I."

One male and one female with the same cage and date label but without the accession number.

One male and nineteen females from other cage numbers, with 1914 dates and initialed "M.A.B."

Two males and seven females from Canlubang River, one male and two females from Capatagan River, and one male from Cristobal River.

Six males and ten females from other localities (Calamba, Magdalena, Los Baños, Pansol River, Antipolo, Lilio, Siniloan, San Pablo, and Santa Rosa).

Of the above, two of the males (one from the same cage as the type and one from another cage) have very small humeral spots such as occur in some male specimens of *flavirostris* and upon dissection one of these proved to have a *flavirostris* type of claspette (with inner hairs, although not quite typical). The abdomen of the other one is missing. Six other males from the series having well-marked humeral spots proved to have hypopygia similar to my *mangyanus* series (without an inner harpagonal hair and with the mesosomal leaflets more than 33 μ long). These included one male from Canlubang River, one from Capatagan River, and one from Cristobal River, all near Canlubang.

Of several female specimens in which the wing fringe is still intact none have a fringe spot at vein 6.[8] Most of the palpi have two broad distal white bands but the subapical one is narrowed in two or three specimens.

Those without a humeral white spot consist of:

One male and three females from Canlubang and Capatagan Rivers. (None from cages.)

Three males and fourteen females from other localities in Laguna Province.

Two of these males, including one from Canlubang River, had, as expected, the *flavirostris* type of harpagonal hairs and a number of the females show the characteristically pale proboscis.

[7] The author states in the original description of the male that the basal third of the wing costa is dark. The labeled specimen, however, has a double interruption.

[8] Walker and Barber also refer to the dark wing fringe at vein 6.

In summarizing the examinations it is found that only four (10 per cent) of forty-one Canlubang specimens were probably var. *flavirostris*, with two other specimens (males) doubtful. None of the twenty-one females from cages could be classified as that species. The much larger proportion of *flavirostris* among the specimens from other localities probably has no bearing on the type of material used in the experimental work.

During 1929, two collections, one in January and one in February, were made by Mr. J. J. Mieldazis and myself at Canlubang. While only part of the specimens from these lots were saved, the mounted material and descriptive notes show that four of them are referrable to the species now defined as *mangyanus*, three to *filipinæ*, and twenty-eight to var. *flavirostris*.

Further collections in October, 1931, show a still smaller proportion of *mangyanus*, only one being identified out of 280 *flavirostris* larvæ examined.

The present preponderance of *flavirostris* larvæ may, I think, be attributed to changed breeding conditions. On the occasion of my last visit I talked with a Filipino who has been employed as a nurse at the Canlubang hospital for many years and was so employed in 1913 and 1914. He accompanied me to one of the nearby streams (Canlubang Creek, or "River"), where Doctor Barber had made collections, and stated that the condition of the stream was considerably changed as regards the amount of tree growth along the banks. An indication of the change is the fact that *maculatus* larvæ are now abundant and any number could be obtained, whereas Walker and Barber state that this species was comparatively rare in 1914.[9]

The 1929 collections demonstrated the presence of all three species at Canlubang, and while there is still a possibility that the type of *M. febrifer* is the same as *filipinæ*, it seems quite remote when the entire series is considered. So large a proportion of specimens with humeral white spots would be exceptional

[9] Another interesting point brought out in connection with the apparent change in breeding conditions is that the malaria rate among the laborers was said to be fairly high in 1913 and 1914 but almost negligible now, although *flavirostris* larvæ are still plentiful. The manager of the sugar company, Mr. L. Weinzheimer, also stated that in his experience the worst malarial outbreaks have occurred during the clearing and developing of new lands and several instances were cited by him in support of this, a further suggestion of a correlation with the habits of *mangyanus*.

for *filipinæ* and most of the palpal markings do not indicate that form. Fringe spots at vein 6 are lacking and their absence is also specifically noted by Walker and Barber. Furthermore, the length of the mesosomal leaflets (Table 3) corresponds more closely to my series of *mangyanus* than to *filipinæ*.

The occurrence of the three closely related forms on one island is of unusual interest, though it does add considerably to the difficulties of identification. On my part, its presence was first suspected while studying certain specimens that had been identified either as *minimus* or "*minimus* variety" (= *filipinæ*) but which were not typical for either one. The first examples were thought to be merely extreme variations, although as the series became larger other larval differences were discovered and these were found to be correlated with a different combination of adult characters. An "intermediate" type of larva that is very likely the same form has also, I understand, been independently observed by Mr. D. Santiago among collections made by him in the vicinity of Calauan, Laguna Province.

Several hundred larvæ of this species have now been critically examined and more than a hundred reared adults are available in my collection. While the identification of the larva is a comparatively simple matter, more difficulty may be expected with some of the less typically marked adults for which the larval molt is not available.

Female.—Proboscis dark scaled. Palpal bands (Plate 2, fig. 5) variable; similar to those of var. *flavirostris* in many specimens, but the subapical white band is slightly shorter on the average and is sometimes reduced to about the width of the subapical dark band; the two white bands occasionally continuous.

Wings (Plate 1, fig. 3) with presector and humeral costal white spots in all specimens and almost always well marked; subapical and subcostal white spots usually from one-half to three-fourths the length of the subapical costal dark spot; vein 3 with the central two-thirds white; vein 4.1 with a few white scales or a definite patch on a third (36 per cent) of the specimens but white spots on veins 2.1 and 2.2, and on the subapical dark spot of vein 1 not noted; vein 5.1 usually with a white spot in the center; vein 6 usually with two dark areas, occasionally only one; fringe opposite vein 6 dark in all except two specimens.

Male hypopygium.—Mesosomal leaflets (fig. 8, *c*) usually five in number, similar in length to those of *minimus* and variety *flavirostris* but longer than those of *filipinæ;* average length of longest leaflet, 36 μ.

Inner hairs of claspette (fig. 7, *c*) usually lacking, being present in only two of seventeen specimens. In one of these the hairs are short and in the other they are about the length of the shortest ones in *flavirostris.* In both cases they are associated with duplication of some of the other hairs (a double apical hair on one side in each specimen, one outer hair double and one club double).

Larva.—Inner anterior clypeal hairs (fig. 1, *b*) long and simple; outer more than half as long, usually simple but occasionally forked; posterior hairs longer than those of *flavirostris,* usually extending perceptibly beyond the base of the anterior pair; inner occipital hairs similar to *flavirostris,* the outer with a slightly greater average number of branches; branching of submedian prothoracic hairs intermediate between *flavirostris* and *filipinæ,* usually from 18 to 23; bases of these hairs seldom fused; thoracic palmate hairs (fig. 3, *c*) end in a long slender filament, quite distinct from the shape of the leaflets in *flavirostris;* filament of abdominal leaflets also longer, ratio to blade 0.88 compared with 0.54 (Table 5); antepalmate hairs of abdominal segments 2 and 3 intermediate between *flavirostris* and *filipinæ,* tending to branch toward the center. The character is variable, however, and the hair on segment 2 may be branched from near the base while that on segment 3 may be branched near the tip, or sometimes simple; antepalmate hairs on segments 4 to 6 simple; that on segment 7 *also simple,* occasionally forked distally.

Anterior tergal plates (fig. 4, *b*) on segments 1 and 2 similar to those of *flavirostris,* the plate on segment 1 being oblong and that on segment 2 crescent-shaped with the posterior edge deeply indented (several specimens with the small median plate incompletely separated and one with this plate completely fused with the main plate); tergal plates on the other segments more nearly similar to *filipinæ* except that the ends are not quite so square. The central portion of the posterior edge of the plate is more or less straight, instead of convex as in *flavirostris,* and the ends are usually more broadly rounded; anterior tergal hairs usually arise from the plate, often deeply placed but sometimes

near the edge either on or off the plate; small submedian plates usually well chitinized as in *filipinæ*.

The larvæ are heavily pigmented dorsally like *flavirostris*, except that the opaque white spots are more abundant and, on the thorax, are collected into two rather definite, submedian white streaks or lines. Ventrally, the abdominal segments have inverted **T**-shaped patches of pigment.

Although some of the larval characters resemble those of *flavirostris*, some *filipinæ* and others are intermediate, the combination is quite distinctive. The simple clypeal hairs and the shape of the first two tergal plates distinguish it from *filipinæ* while the shape of the thoracic palmate hairs and the simple antepalmate hair on segment 7 separate the species from *flavirostris*. For confirmation of identification, the length of the posterior clypeal hairs, the number of branches in the submedian thoracic hairs, the position of branching of the antepalmate hairs on segments 2 and 3, the shape of the tergal plates (after the second), the position of the tergal hairs and the pigmentation are useful.

My collection records show its occurrence in the following localities: Nayon, Ifugao (1929), Calauan, Laguna, (1929), Canlubang, Laguna (1929 and 1931), Los Baños, Laguna, (1931), near Atimonan, Tayabas (1931), Abucay, Bataan (1931), Bongabong, Nueva Ecija (1932), all on Luzon, and Gumbala-on and Fabrica, Negros Island (1931). I have also examined specimens received from Drs. P. F. Russell and R. L. Holt from Masbate Island and from the provinces of Camarines Sur, Sorsogon, and Albay, Luzon.

The collection at Fabrica, Occidental Negros, was made in a mountain stream, on the banks of which were the remains of a logging camp, abandoned, according to the statement of Mr. M. E. Grey, manager of the Insular Lumber Company, because of a severe and persistent outbreak of malaria among the laborers.

Collections of *mangyanus* at Bongabong, Los Baños and on the eastern side of Bataan Province were also associated with locally reported malarious areas. Taken in conjunction with the records from Canlubang its connection with malaria transmission is very definitely suggested. It has not as yet, however, been identified from malarial foci on Mindanao, Jolo or Tawi Tawi.

ANOPHELES FILIPINÆ Manalang.

Anopheles minimus varieties 1, 2, and 3, BAISAS, 1927.
Also "*minimus* variety" of Philippine authors.
Anopheles aconitus var. *filipinæ* MANALANG, 1930.
Anopheles filipinæ CHRISTOPHERS and PURI, 1931.

This species was separated from *minimus* on the basis of the branched clypeal hairs and because of this character was considered to be closely related to *aconitus*. Except for this resemblance, however, there appears to be little reason for considering their relationship any closer than that of some of the other species, and as a matter of fact the form of branching is not identical. The inner clypeal hairs of *aconitus* (fig. 1, *f*) are more coarsely frayed and the outer hairs are frayed also instead of being simple or forked as in *filipinæ*. The tergal plates of *aconitus* (fig. 5, *a*) are smaller and more pointed, the anterior tergal hairs arise from the edge of or off the plate, and are typically two or three branched in the specimens examined. The characteristically pale proboscis of the female of *aconitus* is lacking in *filipinæ*.

I am therefore in agreement with Christophers and Puri in separating it as a distinct species.

Female.—Proboscis dark or with only an indefinite paling toward the tip; typical palpi (Plate 2, fig. 6) have the subapical black and white bands of nearly equal width and about half as wide as the apical white. The markings are subject to variation, however, and some specimens approach the typical *flavirostris* form while in others the subapical white is reduced to a very narrow band.

Wings (Plate 1, fig. 2) with a humeral white spot or a few white scales in 55 per cent of the specimens; presector white spots present in all; veins 2.1 and 2.2 occasionally with a few white scales or a definite spot centrally; vein 3 with dark spots near the crossvein and tip and with the central two-thirds of the vein white; vein 5.1 usually with a central white area; vein 6 with a fringe spot at its tip in a majority of specimens and with a white interruption on the apical half, producing three dark spots on the vein, in about one-fourth (27 per cent) of the specimens.

The form of the palpal banding, the frequent presence of a humeral white spot, of three dark spots on vein 6, the fringe spot at its tip and the absence of definite pale scaling on the proboscis distinguish the female from *flavirostris* in the ma-

jority of specimens. The same characters, with the exception of the humeral spot and the dark proboscis, apply to *mangyanus*.[10]

For identification based only on adult characters, specimens in fairly good condition are required and even then the determination will be doubtful in certain cases in which the typical combination of characters is lacking.

Male hypopygium.—Inner hair of the claspette (fig. 7, *e*) lacking in all specimens examined; outer hair similar to that of *flavirostris.*

Leaflets of the mesosome (fig. 8, *d*) slightly but apparently constantly shorter than those of the other local species; average length of longest leaflet, 30 μ, compared with an average of 36 μ for *flavirostris* and *mangyanus.*

Larva.—Inner clypeal hairs (fig. 1, *e*) finely frayed in all specimens examined except one and in this specimen one of the hairs was simple and the other had only one or two of the fine side branches; outer clypeal hairs unfrayed but frequently forked or trifid; posterior clypeal hairs usually branched from two to four times near the base, sometimes simple; the inner occipital hair typically 3-branched near the base, with variation of from 2 to 8 branches; outer occipital with similar variations; inner submedian prothoracic hairs (fig. 2, *c*) distinctly less branched than in the majority of var. *flavirostris* specimens, the average being 16.8, with variations from 12 to 22; leaflets of thoracic palmate (fig. 3, *b*) more or less intermediate in shape between *flavirostris* and *mangyanus* and more variable, usually tapering to a fine point or short filament; comparative length of filament of abdominal leaflets also intermediate—ratio to blade, 0.63 (Table 5); antepalmate hairs (see fig. 2, *g*) of segments 2, 3, and 7 almost invariably branched from the outer half, sometimes at the extreme tip, instead of from near the base as in *flavirostris;* tergal plates (fig. 5, *b*) of segment 1 comparatively broad and convex posteriorly; plate on segment 2 larger and also convex posteriorly instead of indented as in *flavirostris* and *mangyanus;* tergal plates on the other segments comparatively large and more rectangular in shape, the ends nearly as broad as the central portion; anterior tergal hairs arise

[10] Since the descriptions were written, it has been observed that *filipinæ* differs rather constantly from *mangyanus* in having small but definite pale spots at the apex of some of the tarsal segments, especially the first segment of the fore tarsi.

from the plates, well away from the edge as a rule, and are usually simple; small posterior (submedian) plates usually well chitinized and plainly visible.

The larvæ are much less pigmented subdermally than those of *flavirostris* or *mangyanus* and the tergal plates are not obscured as they frequently are in the other species. The larvæ are usually distinctly lighter in color than those of *flavirostris*.

The species was not identified in my collections of *minimus* from Negros or Mindanao. From the present records it appears to be the least common of the three species in central and southern Luzon and there is as yet no experimental evidence of its connection with the transmission of malaria.[11]

SUMMARY OF THE PRINCIPAL DISTINGUISHING CHARACTERS OF THE PHILIPPINE SPECIES OF THE FUNESTUS-MINIMUS SUBGROUP (WITH THE GENITALIC CHARACTERS OF THE TYPE FORMS OF FUNESTUS AND MINIMUS)

FEMALES

Anopheles minimus var. flavirostris.—Basal third of wing costa with one white interruption (the presector white spot), or entirely dark; subcostal white spot usually less than two-fifths the length of the subapical costal dark spot; vein 6 with one or two dark areas; fringe opposite the vein practically always dark. Proboscis with distinct pale scaling ventrally and laterally on apical half; palpi with the two distal white bands of about equal width and on an average twice the width of the intervening dark band.

Anopheles mangyanus.—Wings regularly with a double interruption on the basal third of the costa and usually with two dark spots on vein 6; fringe opposite vein 6 usually dark; subcostal white spot more than half the length of the subapical dark spot in the majority of specimens. Proboscis dark scaled; palpi fairly similar to var. *flavirostris* as a rule, sometimes without the dark subapical band. Apex of tarsal segments not pale scaled.

Anopheles filipinæ.—Basal third of costa with one or two white spots; vein 6 with two or three dark spots and usually with a

[11] In recent collections (April 1932) from one of the northern Provinces, however, *filipinæ* larvæ proved to be the predominating form in at least two places where malaria is highly prevalent. In these breeding places it was not particularly associated with growths of aquatic vegetation such as those referred to in an earlier part of the paper.

light fringe spot at the tip. Proboscis dark; palpi with the subapical white and dark bands of about equal width and usually about half that of the apical band. Apex of first tarsal segment of fore tarsi and usually some of the other tarsal segments with at least a few pale scales.

MALE HYPOPYGIUM

Anopheles minimus var. flavirostris.—A long inner claspette hair regularly present, of about the same size and length as the outer hair and two-thirds as long as the apical hair. Mesosomal leaflets of medium size, the longest leaflet having an average length of 36 μ.

Anopheles mangyanus.—Inner claspette hair usually lacking, or if present (2 of 17 specimens) may be short or associated with a duplication of the other hairs; outer and apical hairs similar to those of var. *flavirostris* and *filipinæ*. Leaflets of mesosome similar in size to var. *flavirostris* but more frequently number five on each side instead of four.

Anopheles filipinæ.—Inner claspette hair lacking. Mesosomal leaflets uniformly shorter than those of the two previous species; average length of longest leaflet, 30 μ.

Anopheles minimus (*type form*).—Inner claspette hair variable—a short hair may be present on one or both sides or lacking on both. Characters otherwise similar to var. *flavirostris.*

Anopheles funestus.—Inner claspette hair lacking or, if present (one of six specimens), very short; outer claspette hair very short and stout, less than half the length of the apical hair or club; the latter unusually large and expanded and nearly as long as the apical hair. Mesosome and leaflets unusually long; average length of longest leaflet, 49 μ.

LARVÆ

Anopheles minimus var. flavirostris.—Clypeal hairs simple and unfrayed, outer and posterior occasionally forked; the posterior hairs as a rule do not extend beyond the base of the inner (with the head in a horizontal position); inner submedian prothoracic hairs usually with more than 21 branches; leaflets of thoracic palmate tapered to a short point, without a filament; tergal plate of segment 1 narrow, oblong; plate of second segment deeply concave with the small median plate or a portion of the main plate detached; tergal plates on segments 3 to 7 usually convex posteriorly and narrowed toward ends; anterior tergal hairs (hair O) usually arise well away from the plate; antepalmate hairs (hair 2) of segments 2, 3, and 7

branched from the basal third; dorsal surface of larva with heavy subdermal pigmentation.

Anopheles mangyanus.—Clypeal hairs similar to the above except that the outer and posterior are longer, the latter extending to or nearly to the edge of the clypeus; inner anterior prothoracic hairs usually with from 18 to 23 branches; leaflets of thoracic palmate hairs with a fine filament; tergal plates of segments 1 and 2 similar to var. *flavirostris*, those of segments 4 to 7 with broader ends; small submedian plates usually chitinized; anterior tergal hairs usually arise from the tergal plate, sometimes near the edge either just on or just off the plate; antepalmate hairs of segments 2 and 3 usually branched from the middle third; antepalmate hair of segment 7 simple, or occasionally forked apically; larvæ pigmented dorsally with abundant spots of opaque white that are collected into submedian streaks on the thorax.

Anopheles filipinæ.—Inner clypeal hairs finely frayed, outer rather frequently forked or trifid; posterior usually branched two to four times from base; inner anterior prothoracic hairs usually with less than 21 branches; thoracic palmate hairs usually with a short, filamentous end; tergal plates of segments 1 and 2 broad and convex posteriorly; those of other segments very broad and oblong; tergal hairs deeply placed on plates. The larvæ are very sparsely pigmented and have only a few scattered spots of opaque white.

GENERAL SUMMARY

The *funestus-minimus* subgroup of *Anopheles* is represented in the Philippines by three species, one of which has previously been confused with the other two. This species appears to agree with the type specimen of *Myzomyia mangyana* Banks and also with that of *Myzomyia febrifera* Banks (both of which have always been regarded as synonyms of *Anopheles minimus*) and the name *Anopheles mangyanus* is provisionally assigned to it.

Comparative descriptions of the three species are given, together with new descriptive notes on the type forms of *Anopheles funestus*, *Anopheles minimus*, and *Anopheles aconitus*.

The Philippine form of *Anopheles minimus* differs in certain respects from specimens of the type form from China and its separation as a variety, or subspecies, under the name of *Anopheles minimus* var. *flavirostris* Ludlow, seems to be justified.

This is the best known of the three local species and during recent years has come to be considered the only Philippine *Anopheles* of serious importance in the transmission of malaria. Nearly all the evidence, however, has been obtained without distinguishing between the different members of the subgroup and it now appears that all three forms should be suspected as carriers until definitely proved otherwise. The probability that most of the experimental results with "*Anopheles febrifer*," reported by Walker and Barber in 1914, are attributable to *A. mangyanus*, as here defined, rather var. *flavirostris*, implies that this species is readily susceptible to infection with malaria parasites. In addition, *mangyanus* is found to occur in situations with which malaria is usually associated in the Philippines.

The third species, *Anopheles filipinæ* Manalang, appears in general to be the least plentiful of the three in central and probably in southern Luzon. While it has not previously been under suspicion as a carrier-species, recent observations in one of the northern provinces have shown it also to be abundant in places where the disease is unusually prevalent.

These species are small-stream breeders and all three occur on Luzon Island. Although preferences are shown for different types of breeding places, they are frequently more or less closely associated. In view of their morphological differences under these conditions it is evident that interbreeding does not normally occur and they must, therefore, be regarded as distinct species rather than varieties of one.

Certain differences in the male genitalia have been found in the five members of the subgroup of which male specimens are available, the examinations including the African *funestus* and the type form of *minimus* from China. The occurrence of unusually distinctive characters in the case of *Anopheles funestus* is further evidence of its specific differentiation from the Oriental species.

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ILLUSTRATIONS

[From camera lucida drawings.]

PLATE 1. FEMALE WINGS

FIG. 1. *Anopheles minimus* var. *flavirostris*, two wings.
2. *Anopheles filipinæ*, two wings.
3. *Anopheles mangyanus*, wing.

PLATE 2

FIG. 1. *Anopheles funestus*, wing.
2. *Anopheles minimus* var. *flavirostris* (two specimens), distal palpal bands.
3. *Anopheles minimus* (Hong Kong specimen), distal palpal bands.
4. *Anopheles funestus*, palpal bands.
5. *Anopheles mangyanus*, palpal bands.
6. *Anopheles filipinæ*, palpal bands.
7. *Anopheles aconitus*, palpal bands.
8. *Anopheles minimus* var. *flavirostris*, lateral view of the proboscis of two specimens, the second one representing the more typical appearance.

TEXT FIGURES

FIG. 1. Larval clypeal hairs; *a*, *Anopheles minimus* var. *flavirostris*; *b*, *Anopheles mangyanus*; *c*, *Anopheles minimus* (type form); *d*, *Anopheles funestus*; *e*, *Anopheles filipinæ*; *f*, *Anopheles aconitus*.
2. Various larval hairs; *a*, submedian prothoracic hairs of *Anopheles minimus* var. *flavirostris*; *b*, bases of the submedian prothoracic hairs of *Anopheles funestus*, showing the type of fusion in this species; *c*, submedian prothoracic hairs of *Anopheles filipinæ*; *d*, inner (left) and outer occipital hairs of *Anopheles funestus*; *e*, inner occipital hair of *Anopheles minimus* var. *flavirostris*; *f*, antepalmate hair from abdominal segment II of *Anopheles minimus* var. *flavirostris*; *g*, the same of *Anopheles filipinæ*.
3. Thoracic palmate hairs (*a* to *c*) and leaflets of abdominal palmates from segment IV (*d* to *f*); *a*, *Anopheles minimus* var. *flavirostris*; *b*, *Anopheles filipinæ*; *c*, *Anopheles mangyanus*; *d*, *Anopheles minimus* var. *flavirostris*; *e*, *Anopheles mangyanus*; *f*, *Anopheles filipinæ*.
4. Tergal plates; *a*, *Anopheles minimus* var. *flavirostris*; *b*, *Anopheles mangyanus*.
5. Tergal plates; *a*, *Anopheles aconitus*; *b*, *Anopheles filipinæ*.
6. Tergal plates and examples of variations in the shape of plate II; *a*, *Anopheles minimus* (type form); *b*, *Anopheles funestus*.
7. Claspette hairs of male hypopygium; *a*, *Anopheles minimus* var. *flavirostris*; *b* and *c*, *Anopheles minimus* (type form), the second figure showing a short inner hair; *d*, *Anopheles mangyanus*; *e*, *Anopheles filipinæ*; *f*, *Anopheles funestus*.
8. Mesosomal leaflets; *a*, *Anopheles minimus* var. *flavirostris*; *b*, *Anopheles minimus* (type form); *c*, *Anopheles mangyanus*; *d*, *Anopheles filipinæ*; *e*, *Anopheles funestus*.

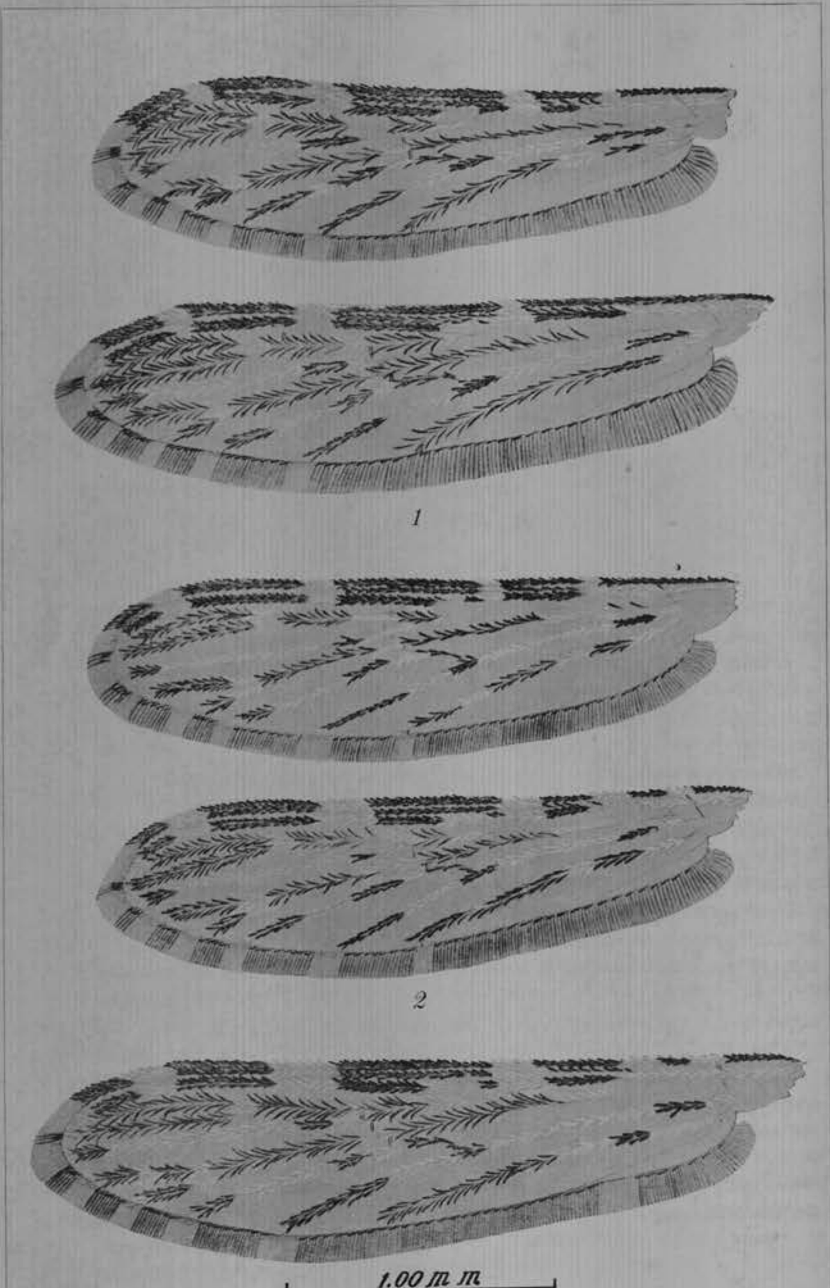

PLATE 1.

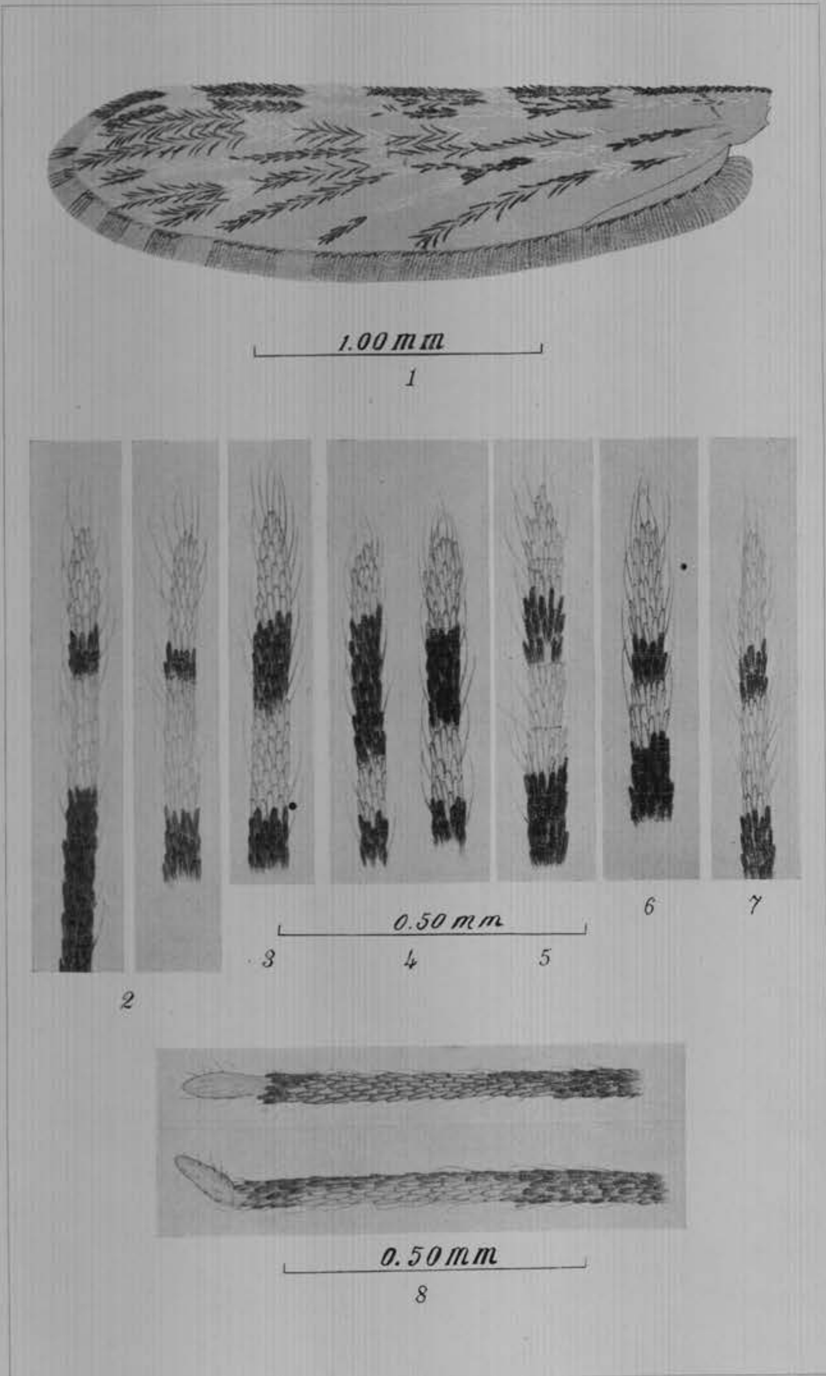

PLATE 2.

MORE PHILIPPINE ISLANDS FRESH-WATER SPONGES

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FIVE TEXT FIGURES

INTRODUCTION

Some months ago the writer completed a restudy of the available materials of fresh-water sponges from the Philippine Islands and published a brief paper [1] summarizing our knowledge of the four known representatives of this group in the Islands up to that date. At the same time request was made for the collection of additional specimens from that region. We received, in response to this request, from R. C. McGregor, of the Philippine Bureau of Science, a collection of sponges that had been made by Francisco Rivera from Pasig River, between Pasig and Laguna de Bay, near Manila, in October, 1930. The very interesting collection consists of a number of small colonies most of which were found growing on plant roots, stems, or other similar small supports that had been submerged in the water. None of the colonies are very large and in many cases only the merest bits of sponge or bare layers of gemmules are present forming thin crusts of small area or covering the entire supports. Fortunately, nearly all of these were bearing gemmules.

The sponges in this collection represent four species, all of which are new records for the Philippine Islands, making now a total of eight species of fresh-water sponges, representing three genera, recorded from that region. Two of these new forms are *Spongillas*, one is an *Ephydatia*, and the other is a *Trochospongilla*.

Trochospongilla latouchiana var. *pasigensis* is a new variety of a form common in parts of India, Java, and China and it has been recently described in my monograph on the *Trochospongillas*.[2] A brief discussion of the points of difference be-

[1] Philip. Journ. Sci. 46 (1931) 61–75.
[2] Peking Nat. Hist. Bull. No. 2 6 (1931) 1–32.

tween this variety and the typical form, together with an illustration of the spicules of the new variety, is included in this paper. The three other forms are described in detail and are also illustrated in the following pages.

It is to be hoped that further collections of sponges from the fresh waters of the several islands will be made, for it is certain that other interesting forms will be found. The writer would be glad to study any additional specimens.

The records of occurrence of fresh-water sponges to date[3] are as follows:

1. *Ephydatia fortis* Weltner, 1895,
2. *Spongilla clementis* Annandale, 1909.
3. *Spongilla microsclerifera* Annandale, 1909.
4. *Spongilla philippinensis* Annandale, 1909.

The following additional forms were found in the above-mentioned collection:

5. *Spongilla tinei* sp. nov.
6. *Spongilla luzonensis* sp. nov.
7. *Ephydatia fluviatilis* var. *meyeni* (Carter), 1849.
8. *Trochospongilla latouchiana* var. *pasigensis* Gee, 1931.

SPONGILLA TINEI sp. nov. Fig. 1.

Historical statement.—In the collection mentioned above there are several specimens of this sponge. Some of them seem to have been collected dry and others show quite clearly evidences of having been taken fresh and living from the river. Specimen 54749 is used as the type for the description that follows.

Habitat.—Almost without exception these sponges were growing on the plant supports of various kinds which seem to be abundant in the river. They would doubtless have covered almost any kind of support available, however, and the specimens sent were those on plants since these were the most convenient kind for handling and transporting.

General characteristics.—This sponge forms a thin covering, the average one is only 3 or 4 millimeters thick, though one specimen measured as much as 1.25 centimeters in thickness on its supports, and in almost every case it is heavily laden with sand grains and other sediment. The surface of the sponge is very irregular due to the vertical fibers of the upper portion of the sponge projecting through the surface membrane in small sharp clusters. At times the sponge is barely thick enough to cover

[3] Philip. Journ. Sci. loc. cit.

the layer of gemmules attached to the stick; in other specimens it is thicker and the gemmules are crowded into the lower half of the sponge while the upper half is generally free of gemmules.

Color.—The body of the sponge would probably be almost a clear white if it were in clean water and free from sediment, for its individual fibers are often white when no foreign coloring matter is present. As it is full of sediment, however, it becomes a grayish color or even darker to almost black where the foreign matter caught in its meshes is abundant.

Structure.—The thinner specimens are composed of large irregular meshes which cover the single layers of gemmules and have no other definite distinguishing structure. The fibers which make up the meshes are bound together by an abundance of spongin and it often forms a film between the sides of the meshes. These films catch a good deal of sediment. In the thicker specimen the lower half of the sponge is similar to that just described and large numbers of gemmules are crowded into the meshes, but the upper portion of the sponge forms distinct, strong vertical fibers often composed of as many as eight or ten spicules firmly bound together. These fibers often extend beyond the surface of the sponge forming strong and sharp points. While there seems to be no definite system of transverse fibers, yet the vertical ones are bound strongly together by irregularly arranged short fibers or groups of spicules. When dry, the sponge is quite brittle and in making sections for study, it is easily shattered and the gemmules in the body of the sponge are dislodged in large numbers. The basal attachment of the specimens with layers of gemmules is quite solid and the gemmules are not readily shaken loose from the support in handling.

Skeleton spicules.—The skeleton spicules of this, as well as of the three other sponges found together in Pasig River, are in the main quite thin as compared with sponges of the same kind from other parts of the world. One wonders whether this is due to the small amount of silica available in the water or to the nature of the sponge itself. They are generally also slightly curved and smooth. Some of them are of a nearly uniform diameter throughout most of their length and become abruptly sharp pointed at their ends; others taper more or less gradually from the center to their ends forming fine, very sharp points. The central canal is visible in many of the spicules.

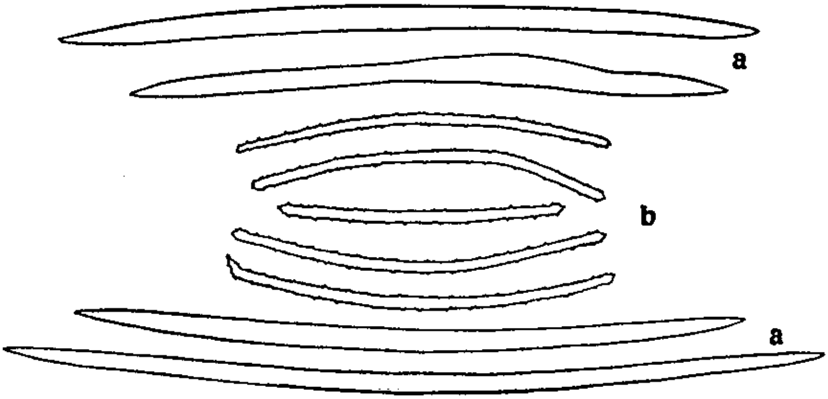

FIG. 1. *Spongilla tinei* sp. nov.; *a*, long slender skeleton spicules; *b*, finely spined gemmule spicules, with spines extending to the very ends; ends of spicules sometimes more finely drawn out than in the ones illustrated here.

Bulbous swellings are very common on these spicules in some of the specimens. The bulbs vary in number from one or two to six or even seven, and they are nearly always symmetrically placed along the axis of the spicules. When the number of swellings is odd, one is usually in the center and the others are similarly arranged on each side of it; when the number is even, the center usually has no swelling and the two ends bear similarly placed bulbs. A few of the spicules are much enlarged and bear large swellings, but frequently the swellings are small and occur on spicules of nearly normal dimensions.

The normal spicules (No. 54754) vary from 196 to 248 microns in length and from 4 to 10 microns in thickness. The larger numbers of spicules vary around about halfway between these extreme measurements.

Flesh spicules.—No flesh spicules were observed. A large number of very small, fine, smooth, sharp-pointed spicules are found in specimen 54759 along with the regular skeleton spicules. These are considered as young undeveloped skeletal spicules in the growing sponge and are not to be confused with flesh spicules.

Gemmules.—The somewhat flattened spherical gemmules are very abundant in all the specimens; they may occur singly or grouped in twos or threes with their bases together and the pore tubes projecting outward at the opposite side from the point of contact or they may occur in continuous layers in the base of the sponge entirely covering their supports or scattered

in groups or sometimes singly through the lower portion of the sponge. They are held in position by the meshwork of the sponge. In one case (No. 54755), they covered almost the entire area of a stick 1.5 centimeters in diameter and 17 centimeters long in one continuous layer. They are yellowish brown and are uniformly arranged with the single pore tube almost perpendicular to the support. The pore tube projects beyond the surface of the gemmule and the air-cell coat, which covers the entire surface of the gemmule, surrounds the tube with a chimneylike structure with gemmule spicules arranged in it at times both parallel to and at right angles to the length of the pore tube. The tube projects beyond this supporting structure and is dark brown, almost black, in color. The tube is very frequently curved. When the gemmules are bound together in groups, as often happens in the body of the sponge, the pore tubes project outward after the manner of those in typical *Spongilla fragilis.*

The gemmules are surrounded by a thick layer of polygonal air cells arranged symmetrically one above the other in such a manner that a columnar effect is the result, and it looks as if there is a series of contiguous, perpendicular columns surrounding it entirely. Within and on the surface of this covering the gemmule spicules are irregularly scattered, chiefly in a tangential position, almost never in a vertical one, except around the pore tube.

The gemmules (No. 54749) are moderately large ones, averaging around 430 microns in diameter; ranging from 425 to 468 microns.

Gemmule spicules.—The gemmule spicules are comparatively few in number and are very variable. Some are straight or almost straight with their ends more or less bluntly rounded; these are covered with very minute simple spines throughout their length with the spines in some cases somewhat thicker near the ends than in the central part of the spicule; others are curved, sometimes sharply curved near their ends, and are sharp pointed; these also bear numerous fine spines entirely covering them, frequently more numerous and larger near the ends, giving the end of the spicule a kind of spearhead appearance. Between these two extremes, all kinds of intermediate variations are found, some sharp at one end and blunt at the other, some almost bowed in shape. They vary (No. 54754) from 120 to 150 microns in length and from 2 to 4 microns in thickness.

Type.—The type is preserved in my collection as No. 54749. Cotypes are being deposited in several of the larger museums in other parts of the world.

Distribution.—This sponge is known only from the type locality, where it seems to have grown in great abundance.

Remarks.—The gemmule spicules of this sponge resemble somewhat the very fine ones of the *Spongilla fragilis* group,[4] but the gemmules are not grouped together in a common air-cell arrangement such as is common in the gemmules of that species.

This sponge (54749) resembles *Spongilla crassissima* var. *crassior* (54247)[5] in some respects but can be easily distinguished from it by the following characteristics. The gemmule spicules of *Spongilla crassissima* var. *crassior* are much heavier and bear larger spines; its gemmules are smaller, several are bound together and have a thicker covering layer of air cells and the pore tubes are comparatively longer and more curved than are those of *Spongilla tinei*. The skeleton spicules of *Spongilla crassissima* var. *crassior* are also very much heavier and have rounded ends, whereas those of *Spongilla tinei* are very much thinner and are very sharp pointed.

In some ways *Spongilla tinei* also resembles *Spongilla geei*, but the sponges of the latter species are much more massive and compact. The gemmule spicules of *Spongilla geei* are also in most cases much heavier and are more variable, while those of *Spongilla tinei* do not often vary beyond the two forms described above. The skeleton spicules of *Spongilla geei* are thicker and are usually abruptly pointed. The two sponges are quite distinct.

This Philippine sponge has been compared with many specimens of *Spongilla* and is so different from anything else in my collection or with which I am familiar that it is described as a new species.

SPONGILLA LUZONENSIS sp. nov. Fig. 2.

Historical statement.—These sponges form the larger numbers of specimens in the collection from Pasig River, Manila.

Habitat.—Most of these small sponges, as well as the others in the collection, were growing upon the submerged stems of

[4] Annandale, Fauna of British India: Fresh-water Sponges, Hydroids and Polyzoa (1911) 98–99.

[5] Gee, China Journ. of Sci. and Arts 4 (1926) 235–237.

small water plants or of other plants which had fallen in the water. One small specimen, the type (No. 54790), had grown around three or four small snail shells, the whole mass being about 2.5 centimeters long by about 1 centimeter in its thickest part.

General characteristics.—This sponge usually forms very thin films or crusts, rarely more than 1 to 2 millimeters in thickness, over the surface of the plant supports mentioned above. It may form small patches of a few centimeters in length on larger stems or at times it may even cover entirely the smaller twigs as much as 10 or 12 centimeters long and with a diameter of a few millimeters. It is frequently found growing together with other sponges on the same support and they are often badly mixed up. In this species, as was also the case with the others, some specimens are badly disintegrated as if they had been exposed for some time, while others bear the undisturbed film of the dried dermal membrane indicating that they were taken in a growing condition from the water. The surface of the sponge is usually smooth with no protuberances or other outgrowths from it.

Color.—The sponge itself is almost black, due to the very large amount of sediment which is present in it. The gemmules are dirty white or gray. The amount of sediment in the water is evidently large and this accounts for the color of the specimens.

Structure.—The thin film of sponge (No. 54763) is made up of a rather irregularly arranged series of meshes of varying sizes. The sides of these thin fibers are without any definite arrangement and, when dry the sponge is very fragile. Frequent small-pointed groups or clusters composed of a few spicules bound together by spongin project above the surface of the sponge in the fresh, uninjured specimens.

Skeleton spicules.—The skeleton spicules (No. 54790) are very thin, generally slightly curved, rarely altogether straight. Most of them are smooth, though now and then one bearing very fine spines only visible under high powers of the microscope may be found. They are gradually and very sharply pointed; sometimes bulbous enlargements are found at the center of the spicule. Very often the central canal is clearly visible. They vary from 212 to 238 microns in length and from 3 to 6 microns in thickness.

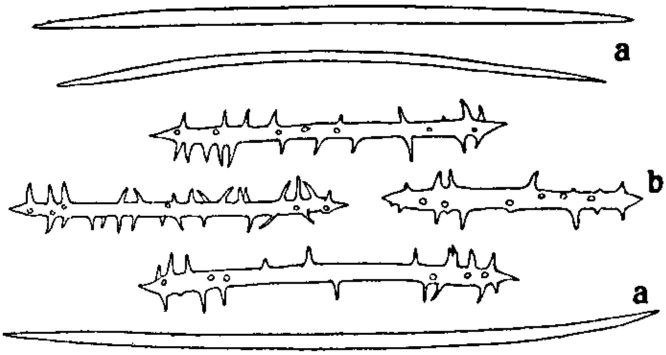

FIG. 2. *Spongilla luzonensis* sp. nov; *a*, very slender, finely pointed skeleton spicules; *b*, typical gemmule spicules bearing heavy spines throughout their length; the lowest one shows fewer spines near the center of the spicule.

Flesh spicules.—No flesh spicules were observed in this species.

Gemmules.—The gemmules are very abundant and form layers in the base of the sponge on the support; they occur singly and though they are often so thick as to be in actual contact they are not united together in groups as is the case in the other species, *Spongilla tinei*, just described in this article. The gemmules are covered by the thin layer of sponge and are inclosed in the meshes of which it is composed. In color, they are white when clean, but all too often they become dirty white or gray due to the large amount of foreign matter contained in the water. In shape, the gemmules are spherical with a projection of the surface of the coat covering the gemmule around the single pore tube into a rounded knob or umbo, or at times a cone-shaped elevation, out of the center of which emerges the small brown pore tube itself. The pore tube is usually curved and may frequently be nearly twice as long as the gemmule spicules. In the projection surrounding the pore tube the gemmule spicules are often arranged in a chimneylike fashion around the tube with their length perpendicular or at right angles to the length of the tube. A single layer of perpendicularly arranged gemmule spicules tightly bound together by granular spongin covers the gemmule as a protecting coat. The gemmules are rather small, they measure from about 212 to 273 microns in their normal diameter; this measurement includes also the perpendicular layer of gemmule spicules surrounding the gemmule.

Gemmule spicules.—The gemmule spicules of this species are small and slender and are very variable. They may be straight or gently curved. There are found now and then cylindrical spicules abruptly sharp pointed and with only one or several spines; others may be thickly covered with spines of varying size, from very fine ones to others with a length equal to or longer than the diameter of the spicule itself, throughout its entire length except on the sharpened ends of the spicule. The spines nearest the end are usually longest and more numerous, they are only very rarely entirely absent in the center of the spicule. The spines are usually simple, straight, and perpendicular to the spicule axis; sometimes, but rarely, a few spines may be found obliquely placed, no hooked or curved ones have been observed. In some cases there are several large spines arranged around the end of the spicule at the base of the terminal spine or sharpened end, in one case a spicule with such spines ended bluntly and the large spines united at their bases resembled an imperfect retule. This was observed in only one or two instances and is not by any means a characteristic of the species; it is rather an exception. These spicules are quite distinct from the *Ephydatia crateriformis* group.

The ordinary spicules vary from about 50 to 62 microns in length and from 2 to 3 microns in thickness. A few much longer spicules were observed, but they were doubtless unusual and abnormal ones.

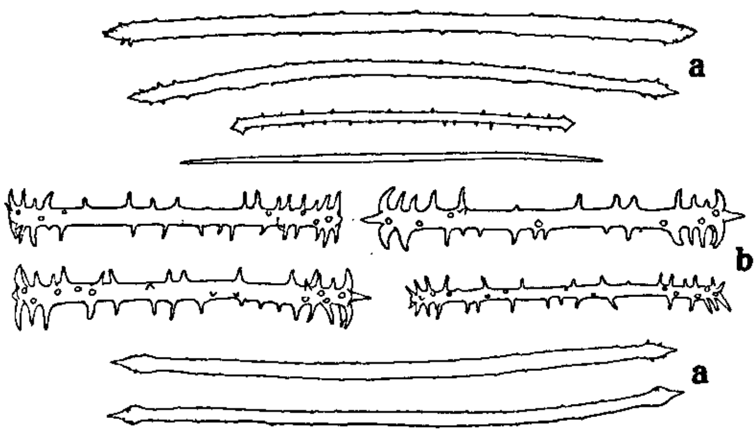

FIG. 3. *Ephydatia crateriformis* (Potts); *a*, finely spined skeleton spicules typical of this Indian sponge; the spear-shaped ends differ very decidedly from the typical form found in the United States; *Spongilla luzonensis*, has no such spicules; *b*, some of these gemmule spicules resemble somewhat those of *S. luzonensis*, but this sponge has many more spines and the ends are definitely surrounded by whorls of spines forming distinct rotules.

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Type.—The type of this species is (No. 54970) in my collection. Cotypes are being deposited in several of the larger museums in other parts of the world.

Distribution.—This species is known only from Pasig River, near Manila, Philippine Islands.

Remarks.—There is some resemblance between *Spongilla hemephydatia*[6] and this species, but the differences between the two species are so marked that they can be readily distinguished.

(1) In the first place the gemmules of *Spongilla hemephydatia* are heavier in structure and are nearly twice as large. They range from 365 to 425 microns in diameter, while those of *Spongilla luzonensis* are only 212 to 273 microns.

(2) The gemmule spicules of *Spongilla hemephydatia* average a little longer and a little thicker than those of *Spongilla luzonensis.* They are from 60 to 63 microns in length and from 4 to 6 microns in thickness. The spines of *Spongilla hemephydatia* are usually smaller and much thicker than in the other form; they are also differently arranged; they are clustered around the ends (see Annandale, fig. 12) and if the spicule ends in a spine it is simply one of the small ones common around its end, not the spicule terminating in a sharpened point.

(3) The skeleton spicules of *Spongilla hemephydatia* are longer and thicker, 297 to 331 by 10 to 14 microns, than those of the Philippine sponge.

Spongilla luzonensis resembles most closely in a number of respects the sponge described by Annandale in 1907 as *Ephydatia indica* (fig. 3) and later in 1911[7] as *Ephydatia crateriformis* and illustrated in fig. 13, A.

(1) The gemmule spicules of the Philippine sponge, *Spongilla luzonensis,* are similar to the sharp-pointed ones illustrated, in fig. 13, A; but as a rule they are not so thickly spined, the spines are larger, and the end of the spicule is more markedly a sharpening of the spicules rather than simply a large terminal spine. In only most rare cases is there a whorl of spines around the end of the spicules of *Spongilla luzonensis* as is the case with many of the spicules of Annandale's sponge *Ephydatia crateriformis.*

[6] Annandale, Fresh-water Sponges, etc., in Fauna of British India (1911) 82–83, fig. 12.

[7] Annandale, op. cit. 83–86, fig. 13.

(2) The gemmules of the two sponges have several points of resemblance, but those of the Indian sponge are considerably larger.

(3) The skeleton spicules of the two sponges are markedly different. Those of *Spongilla luzonensis* are generally smooth and sharp pointed, only rarely in a spicule found incipiently spined, the spines being so small that high magnification is needed to render them visible. Those of the Indian sponge are all clearly spined, they may have rounded, sharpened, or spear-shaped ends.

For the reasons enumerated above, this sponge is considered a new species.

EPHYDATIA FLUVIATILIS var. MEYENI (Carter), 1849. Fig. 4.

Spongilla meyeni Carter, 1849.
Ephydatia fluviatilis Weber, 1890.
Ephydatia mülleri Weltner (part), 1895.
Ephydatia robusta Annandale, 1907.
Ephydatia mulleri var. *meyeni* Annandale, 1908.

Habitat.—The several specimens of this species in the collection were all growing on living or dead plant stems of varying sizes which were submerged in the water of Pasig River. It is understood that the water of this river is very rich in organic matter since it serves as the receptacle for a good deal of the waste from the City of Manila.

General characteristics.—None of the specimens of this sponge are larger than those of the two species of *Spongilla* found with them; some form very thin crusts of only a few millimeters in thickness along their supports, covering them for a few centimeters in length. One of the largest pieces is a lump growing attached to a minute rootlet; it is about 6.5 centimeters long by about 3 centimeters thick in its thickest part. The surface is irregular, showing no special distinguishing structural characteristic, though it is perforated by many small pores. While in most specimens there are no protuberant growths except as they grow around branches of the plant, yet there are one or two specimens which have small and short rounded elevations upon their surfaces. The gemmules are grouped in a layer in the base of the sponge and attached upon the supports; or in the tuberous outgrowths, the gemmules are crowded together near the center of the sponge. In some of the specimens (all

of which are dry) the remains of a dermal membrane still persist, though in most cases it has already disappeared. Since my specimens are all dry, I am not able to observe whether or not the bubble cells are present in the parenchyma.

Color.—In color the sponge is grayish yellowish on the inner areas and this seems to have a decided greenish tinge on the outer parts of the majority of the specimens. Some of the bits that have grown in water more heavily laden with dark sediment are almost black.

Structure.—The basal portion of the sponge next to its support is composed of a rather open network with irregular meshes. The gemmules covered with a few skeleton spicules are often lodged singly in these meshes. The meshes are formed by fibers varying in thickness, some containing only three or four spicules to thicker ones, at times with as many as seven or eight to twelve or even more spicules. The amount of spongin present in this portion of the sponge is small. The outer portion of the skeleton is composed of the thicker fibers and radiating ones can be found, though they are not so clearly defined as are these fibers in *Ephydatia fluviatilis,* common in certain localities in China. These longer fibers are bound together by irregular cross fibers forming an irregular meshwork. The amount of spongin in the upper portion of the sponge is larger than in the basal part and the structure is therefore much more rigid there.

Skeleton spicules.—The mature skeleton spicules are slender, prevailingly smooth, usually slightly curved, rarely straight, of more or less uniform thickness, tapering rather abruptly to sharp points at the ends. The immature spicules are very thin, gradually and sharply pointed at both ends. Scattered throughout the skeletal structure are frequently found in some of the specimens (No. 54760) larger, thicker spicules which have from one to several bulbous enlargements at intervals along their length. These are probably abnormalities and are of no special significance. At times, also, spicules are found bearing fine spines varying in number and size. The regular skeleton spicules range from 187 to 272 microns in length, the usual length is about 235 microns, and from about 6 to 12 microns in thickness.

A specimen of *Ephydatia meyeni* (Carter) (No. 53437) from the British Museum has very much larger and thicker spicules, they measure from 348 to 425 microns long and from 18 to 22 microns in thickness.

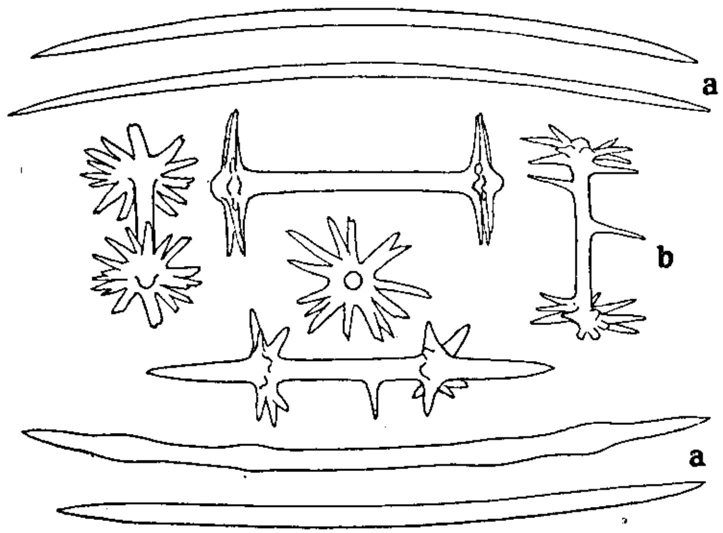

FIG. 4. *Ephydatia fluviatilis* var. *meyeni* (Carter); *a*, smooth skeleton spicules, some of them bear bulbous enlargements regularly placed at intervals along the axis of the spicule; *b*, very irregular gemmule spicules, birotulates, some with smooth shafts, others bearing spines; some show toothlike projections out of the regular plane of the rotule; the lowest one shows the shaft extended at both ends beyond the rotule or disk; this is very common in these sponges.

Flesh spicules.—This species does not have any flesh spicules.

Gemmules.—The gemmules are spherical in shape, but the outer surface of the covering coat is very irregular and uneven. Often they are shrunken in, forming bowl-like structures when they are dry. They are brownish in color and occur singly, but are grouped into layers near the center of the sponge or upon the support; they are held in position within the skeleton meshes by a thin irregular lot of spicules attached to the outer area of the coat surrounding the gemmule. The covering birotulates are arranged in layers, usually more than one, with their shafts perpendicular to the surface of the gemmule. The inner layer of birotulates is quite regular, the second layer is thinner and more irregular, while the remains of a third very irregular layer are found in many of the gemmules as single more or less isolated birotulates here and there over the surface. This is in rather decided contrast with the single, regularly arranged layer of birotulates which forms the covering of typical *Ephydatia fluviatilis*.

The pore tube is a simple, straight one ending on the surface of the gemmule coat. The gemmules are fairly large, often

reaching as much as 575 microns when the outer edges of the coat are included. The usual range in size is from about 425 to 575 microns; when denuded of the covering the gemmule measures about 390 microns.

Gemmule spicules.—The gemmule spicules are variable in length, ranging from 22 to 46 microns in the various specimens measured. The shaft ranges between 4 and 6 microns in diameter, and the rotules, both of which are of about the same diameter, measure from 16 to 28 microns. While in the majority of cases the shafts are smooth, yet now and again rather large sharp spines, at times equalling in length the radius of the rotule or longer, are present; these may number one, two, or even three, but not often more. The shaft forms a distinct umbo beyond the disks, and frequent abnormal forms with the shaft projecting into sharpened extensions of varying lengths at one or both ends are found. The rotules are deeply and irregularly incised; they often bear one or more teeth projecting from the general plane of the disk. The rotules are at times replaced by a bulbous enlargement, which is covered by heavy spines projecting at various angles in addition to the plane of the regular rotule.

The gemmule spicules of *Ephydatia meyeni* (No. 53437), a specimen from India, are somewhat larger and of a more-uniform length than those of the Philippine sponge and they also have more spines on their shafts. The spines are frequently provided with minute secondary spines near their tips.

Type.—The type of *Ephydatia fluviatilis* var. *meyeni* (Carter) is preserved in the British Museum.

Distribution.—Carter's type of this sponge was found on Bombay Island, and the species has since been collected in Calcutta, Cape Comorin, and Bhim Tal in India. Weber found it in Sumatra and the writer has collected it in Soochow, China. This collection from Pasig River, Luzon, extends the range of distribution quite a good deal.

Remarks.—Annandale [8] states that this *Ephydatia meyeni* can be distinguished from *Ephydatia fluviatilis* by the following characters:

1. There are bubble cells in the parenchyma of *Ephydatia meyeni*, they are lacking in *Ephydatia fluviatilis*.
2. The skeleton of *Ephydatia meyeni* has more spongin and is more compact than that of *Ephydatia fluviatilis*.

[8] Annandale, op. cit. (1911) 242.

3. The gemmule spicules of *Ephydatia meyeni* are shorter than those of *Ephydatia fluviatilis*.
4. The gemmules of *Ephydatia meyeni* are covered by more than one layer of birotulates, while those of *Ephydatia fluviatilis* have only one regularly arranged row embedded in pneumatic tissue with minute air spaces.

1. Since my specimens are all dry I cannot discover any bubble cells in the parenchyma of these sponges. 2. The amount of spongin present in a sponge is so variable under different conditions of growth that this alone is hardly an adequate basis for distinction of a species. 3. The length of the gemmule spicules of this sponge is such a variable quantity that I have found specimens with the shaft actually shorter than the diameter of the rotules; this is rare, however, for most of them have shafts decidedly longer than the diameter of the rotule but the length is very far from a constant quantity. Both *Ephydatia meyeni* and *fluviatilis* have such a range in the variations of the birotulates that it would be difficult to separate these two forms on such a basis. 4. This leaves then the only satisfactory basis of separation of the two forms to be by means of the layers of birotulates covering the gemmule. This seems to be fairly constant and is a reason for distinction between the two sponges. Such a slight difference does not deserve specific distinction, however, and I am placing *meyeni* as a variety of *Ephydatia fluviatilis*. While the Pasig River sponge varies a good deal from the typical form of this variety, yet its range of variation connects up fairly well with the type and the multiple rows of gemmule spicules clearly place it within this variety.

The skeleton spicules of the Philippine representative of this sponge are very much thinner than those of the Bombay, India, specimen, but all of the sponges in the entire collection from Pasig River seem to produce comparatively small skeleton spicules. This may be due to a lack of an adequate supply of the proper materials in this river for the formation of the more-robust types of spicules such as are found in other localities.

TROCHOSPONGILLA LATOUCHIANA var. PASIGENSIS Gee, 1931. Fig. 5.

Historical statement.—This new variety of *Trochospongilla latouchiana* was found in the collection of sponges sent me by Mr. McGregor. Just at the time a small monograph on the known sponges of this genus was being prepared and the origin-

al description of this sponge was recorded there. The points[6] of difference between this variety and the typical form are summarized below.

DISTINGUISHING CHARACTERISTICS

Skeleton spicules.—The skeleton spicules of the Philippine variety, *pasigensis*, are shorter and thinner than those of the type form. The spicules of this variety measures from 150 to 189 microns long by 3 to 5 microns thick, while those of the typical form range from 220 to 310 microns long by 8 to 18 microns in thickness.

Gemmules.—The gemmules of the variety average slightly smaller than those of the type form. The gemmules of the variety *pasigensis* range from 170 to 180 microns in diameter, while those of the type form are from 178 to 230 microns in diameter.

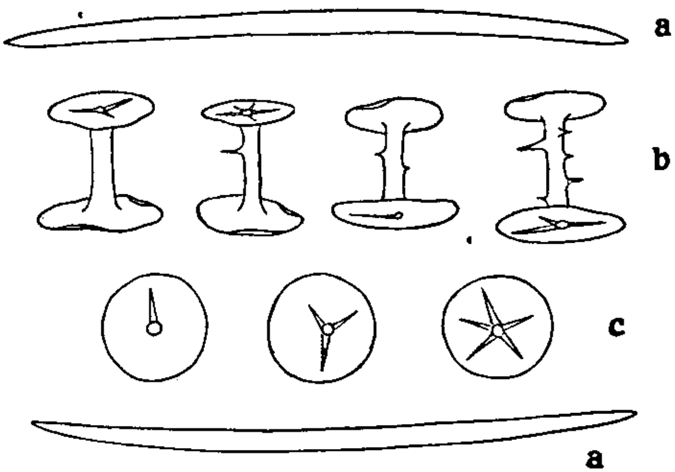

FIG. 5. *Trochospongilla latouchiana* var. *pasigensis* Gee; *a*, skeleton spicules; *b*, gemmule spicules with spined shafts; this condition is not found in the sponges of the type form in India, China, or Java; *c*, on the surfaces of the disks are often found thickened elevations radiating from the center of the disk; these vary in number from one to several.

Gemmule spicules.—The gemmule spicules are very variable, and the following are some of the points in which they differ from the type form:

[6] Gee, Peking, Nat. Hist. Bull. pt. 2 6, (1931–32) 1–32.

SHAFT

1. The variety often bears one or more spines on its shaft; we have never found a spine on the type form.
2. The shaft of the Philippine sponge sometimes projects beyond the rotule forming a long sharp spine. No such condition has ever been observed in the type form.
3. The shaft of the variety is sometimes decidedly curved. This has not been observed in the type form.

ROTULES

1. In the variety the rotules sometimes occur at an oblique angle, instead of the usual right angle, to the shaft.
2. In the variety the rotules, especially the larger ones, often have very heavy radiating ridges upon their lower surfaces, these ridges being largest and thickest near the base of the shaft, becoming thinner and pointed as they near the edge of the disk. The number of these ridges on each may vary from one or two to as many as five or six. The presence of these thickened ridges sometimes gives the disk the appearance of being incised around the edges, but this has not yet been found to be the case in any instance.

Type.—The type from which this variety has been described is preserved in my collection as No. 54784.

Distribution.—This is the only *Trochospongilla* yet found in the Philippine Islands and it has been found only in the type locality.

ILLUSTRATIONS

[I am indebted to Mr. Li, artist in the Department of Anatomy, Peiping Union Medical College, for four of the drawings illustrating this article.]

TEXT FIGURES

FIG. 1. *Spongilla tinei* sp. nov.; *a*, long slender skeleton spicules; *b*, finely spined gemmule spicules, with spines extending to the very ends; the ends of spicules are sometimes more finely drawn out than in the ones illustrated here.

2. *Spongilla luzonensis* sp. nov.; *a*, very slender finely pointed skeleton spicules; *b*, typical gemmule spicules bearing heavy spines throughout their length; the lowest one shows fever spines near the center of the spicule.

3. *Ephydatia crateriformis* (Potts); *a*, finely spined skeleton spicules typical of this Indian sponge; the spear-shaped ends differ very decidedly from the typical form found in the United States; *Spongilla luzonensis* has no such spicules; *b*, some of these gemmule spicules resemble somewhat those of *S. luzonensis*, but this sponge has many more spines and the ends are definitely surrounded by whorls of spines forming distinct rotules.

4. *Ephydatia fluviatilis* var. *meyeni* (Carter); *a*, smooth skeleton spicules, some of them bear bulbous enlargements regularly placed at intervals along the axis of the spicule; *b*, very irregular gemmule spicules, birotulates, some with smooth shafts, others bearing spines; some show toothlike projections out of the regular plane of the rotule; the lowest one shows the shaft extended at both ends beyond the rotule or disk; this is very common in these sponges.

5. *Trochospongilla latouchiana* var. *pasigensis* Gee; *a*, skeleton spicules; *b*, gemmule spicules with spined shafts; this condition is not found in the sponges of the type form in India, China, or Java; *c*, on the surfaces of the disks are often found thickened elevations radiating from the center of the disk; these vary in number from one to several.

PARIS GREEN PARTIALLY ADSORBED ON CHARCOAL AS A LARVICIDE FOR ANOPHELES MOSQUITOES
LARVICIDE STUDIES, II [1]

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and

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Of the International Health Division of the Rockefeller Foundation

TWO PLATES

In a previous article [2] charcoal was suggested as a diluent for Paris green mixtures prepared in the usual way for the destruction of anopheles larvæ. In this paper charcoal is considered not as a diluent in a mixture but as an actual support, or vehicle, with the Paris green adsorbed and carried into the gut of the anopheles larva. The essential difference between charcoal mixed with Paris green and Paris green adsorbed by charcoal is that approximately only one particle in a hundred of a 1 per cent Paris-green mixture is poisonous to the mosquito larva, whereas every granule of charcoal treated with 1 per cent Paris green (adsorbed) carries its load of the toxic substance. Theoretically, a larva "brushing" in the midst of a floating Paris-green mixture ingests 99 grains of an innocuous substance to 1 grain of Paris green. If its breeding place is dusted with the charcoal powder having adsorbed Paris green then every grain ingested contains some poison.

CHARCOAL AS A SUPPORT FOR PARIS GREEN

Wood charcoal is very durable and is not affected by water. For this reason charred stakes driven into moist ground are

[1] These studies were undertaken by the Bureau of Science, divisions of organic chemistry and of malaria investigations. The latter is coöperatively supported by the Bureau and by the International Health Division of the Rockefeller Foundation.

[2] Russell, P. F., and A. P. West, Philip. Journ. Sci. (in press).

more lasting than ordinary stakes; casks, when charred inside, preserve water much better than common casks because they furnish no soluble matter for fermentation. The ancients wrote with inks made from ground charcoal. Their writings found in the ruins of Herculaneum have retained their original blackness for over two thousand years. Inscriptions on tomb stones in old churchyards are still well preserved though the white lead used in painting the carbon-black letters is entirely destroyed.[3]

Porous wood charcoal has the property of absorbing large volumes of gases. It also can remove from aqueous solution various coloring matters, alkaloids, and metallic salts.[4]

In a previous paper[5] it was noted that charcoal has good floating qualities; it is visible after application, easily powdered, and not expensive. Another important quality is its suitability for ingestion by anopheles larvæ. The photographs reproduced herewith give visible evidence of the rapidity with which the gut of an anopheles larva is filled with larvicidal charcoal when the powder is dusted on the surface of the water in relatively small amounts. The larvæ obviously have no aversion to the charcoal and not the least difficulty with its ingestion.

APPLICATION OF PARIS GREEN TO CHARCOAL

The charcoal used in this investigation was powdered sufficiently fine to pass a 50-mesh sieve.

Adsorption of the Paris green and other substances on the charcoal was carried out in the following manner: The charcoal (5 grams) was placed in a beaker and the required amount of Paris green, necessary to make the concentration desired, was then added. The mixture was treated with about 60 cubic centimeters of water, stirred thoroughly, and heated to a temperature of about 90° C. The mixture was then transferred to an evaporating dish and evaporated to dryness. The residue was scraped from the dish and powdered. A sample of larvicidal charcoal prepared in this manner and consisting of 1 part of Paris green to 99 parts of charcoal was regarded as containing 1 per cent of Paris green.

As Paris green alone is rather insoluble in water this treatment gives only a partial adsorption of the Paris green on the

[3] Thorpe, E., Dictionary of Applied Chemistry 1 (1912) 663.

[4] Watts, Dictionary of Chemistry 1 (1927) 686.

[5] Russell, P. F., and A. P. West, Philip. Journ. Sci. (in press).

charcoal. By this procedure the Paris green is partly adsorbed by the charcoal while a portion is simply mixed with the charcoal. The expense of this operation consists essentially in the cost of evaporating the mixture. During the dry season this could be accomplished by means of sunlight thus requiring only the cost of labor.

EXPERIMENTS WITH PARIS GREEN-ADSORBED CHARCOAL

The tables present the results of our laboratory experiments to determine the larvicidal effects of Paris green partially adsorbed on charcoal. In all of these studies a uniform technic has been used for testing this action of larvicide on anopheles mosquitoes. It must be stressed that it is vital in such studies to use standardized methods, with proper controls, to avoid misleading results.

EXPERIMENTAL PROCEDURE

In each of these experiments the same type of rectangular enamel pan was used, the same amount and kind of fresh artesian water, the same method of timing and of removing the dead larvæ. Various but comparable weights of the charcoal larvicide were used, adequate controls were provided, and the same technician assisted at the experiments. Even with all due caution the results of such a biological study are likely to show considerable variation. Others, for example Shannon and Frobisher,[6] have noted the wide differences in the reaction of mosquito larvæ to a larvicide. Individual larvæ differ in their resistance to Paris green. Even using the same development stages of the same species this variation is noted.

The pans used in these experiments were such that the water in them had a surface area of 532 square centimeters and a depth of 5 centimeters. The larvæ in most of the tests were taken from collections in which the predominating species were *A. subpictus* and *A. hyrcanus* var *sinensis*. Those used in the experiments were not individually identified before use in order to avoid the possibility of injury from handling under a microscope. After the experiment an examination was made to confirm the diagnosis of the species. When the larvæ had been counted into the pans the larvicide was blown uniformly over the surface. At the end of each observation period, motionless larvæ were touched gently with a dissecting needle. If a larva

[6] Am. Journ. Hyg. 14 (1931) 437.

made any response whatever, even a very slight contraction, it was not removed. If, however, it could not be stimulated it was removed to a small beaker of water and observed until the end of the experiment to make certain that it had actually been dead at the time it was removed from the pan. Larvæ sometimes recover after showing all appearance of death as reported, for example, by Barnes.[7] In these experiments we rarely found it necessary to return a larva to the pan again.

RESULTS

In Table 1 are given the results of a series of tests on the larvicidal effects of charcoal treated with Paris green and oxalic acid in various concentrations. This combination kills anopheles larvæ quite effectively. It is interesting to note that when the percentage of Paris green is 35 (test 19), the lethal effects of the combination in twenty-four hours are no greater than when the percentage is 7 (test 25). Earlier deaths occur, however, in the stronger combinations. The best results in this series were obtained using 0.1 gram of a 3 per cent Paris green combination (test 80). Ross and Edie[8] tried oxalic acid with indifferent success against culex larvæ. Bodine[9] reported that the larvæ of *Culex pipiens* were resistant to high concentrations of salicylic, oxalic, hydrochloric, butyric, and acetic acids.

When lime instead of oxalic acid was used with Paris green on the charcoal the larvicidal effect was slightly enhanced (Table 2). Very low concentrations of Paris green (tests 94 and 95) proved to be as efficacious as the standard mixtures of Paris green and diluent, 1 to 100, as ordinarily used. (See the table in our first paper[10] for comparison. For example, a concentration of only 0.1 per cent Paris green (test 95) killed 100 per cent of the larvæ in twenty-four hours. Usual field practice as recommended by Hackett[11] requires 1,250 grams of Paris green per hectare (0.125 gram per square meter or 0.0000125 gram per square centimeter). For an area of 532 square centimeters, as in this experiment, this practice would require 0.00665 gram of Paris green or 0.665 gram of the 1 per cent mixture. Actually in test 95 (Table 2), using only 0.1 gram of

[7] Am. Journ. Hyg. 5 (1915) 315.

[8] Ann. Trop. Med. & Parasit. 5 (1911) 385.

[9] Biol. Bull. Marine Biol. Lab. Brooklyn, N. Y. 45 (1923) 149.

[10] Russell, P. F., and A. P. West, Philip. Journ. Sci. (in press).

[11] Trans. 1st. Internat. Congress Malaria, Rome (1925) 158.

the 0.1 per cent larvicidal adsorbed charcoal, there was only 0.0001 gram of Paris green present to kill the larvæ. Had the same relative amount of powder by weight been used as is recommended for field use, the amount of Paris green present in this 0.1 per cent combination would have been 0.000665 gram.

For comparison, in tests 29 and 23 (Table 2), plain lime, and also charcoal treated with plain lime (adsorbed), were used with little effect on the larvæ. Osborn [12] experimented with lime as a larvicide against aëdes larvæ. So also did Paterson.[13] The latter reported it to be potent against culicine larvæ.

In Table 3 are presented the results of tests with Paris green and borax adsorbed on charcoal. In test 93, shown in this table, sodium carbonate was used instead of borax. The results of these tests indicate that borax is not so effective as lime in combination with Paris green, although borax itself has been used as a larvicide.[14]

In Table 4 are given the results of a series of tests in which Paris green and small amounts of arsenic trioxide together with either lime or borax were adsorbed on the charcoal. Very low concentrations of Paris green were used with good effect in some tests. For example, in tests 110, 129, and 134, the percentage of Paris green was only 0.05, with an equal amount of arsenic trioxide.

In Table 5 are given the results of some miscellaneous tests with charcoal treated with Paris green and other substances, for comparison with Tables 1 to 4.

In Table 6 are given the results of some later experiments in which three-fifths of the larvæ used were *Anopheles minimus*, the malaria-carrying species of the Philippines. In these tests the other larvæ were *A. fuliginosus* and *A. philippinensis*. In all of the tests *A. minimus* larvæ were the first to succumb.

SUMMARY

It would appear from the tests discussed in this paper that charcoal treated with small amounts of Paris green (partially adsorbed) has a pronounced lethal effect on anopheles larvæ.

Low concentrations of Paris green, less than 1 per cent, proved to be as efficacious as the standard 1 per cent mixtures of Paris green and diluent as ordinarily used.

[12] Ind. Med. Gaz. 41 (1906) 498.

[13] S. African Journ. Sci. 22 (1925) 311.

[14] Matheson, R., and E. H. Hinman, Am. Journ. Hyg. 8 (1928) 293.

TABLE 1.—*Larvicidal effects of Paris green and oxalic acid partially adsorbed on charcoal.*

Test No.	Substance used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals. Minutes. 15	30	45	60	75	90	105	120	Hours. 2.5	3	4	5	6	24	Weight of larvicide.
		Per cent.																*g.*
12	Control (nothing)	-------	50	0	0	0	0	0	0	0	0	0	0	0	0	0	4	
24	do	-------	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	-------
11	Control; plain charcoal	-------	50	0	0	0	0	0	0	0	0	0	0	0	0	2	6	0.13
5	Paris green Oxalic acid	3 1	52	0	0	0	0	0	0	2	2	18	58	74	86	96	100	0.13
80	Paris green Oxalic acid	3 1	50	0	0	0	0	0	6	20	44	68	76	86	98	100	100	0.1
6	Paris green Oxalic acid	3 2	50	0	0	0	0	0	0	2	2	8	18	52	68	76	86	0.13
7	Paris green Oxalic acid	4 2	50	0	0	0	0	2	2	10	10	24	56	76	98	98	98	0.13
14	Paris green Oxalic acid	4 2	48	0	0	0	0	0	0	0	0	2	6	60	80	84	92	0.01
8	Paris green Oxalic acid	6 2	50	0	0	0	0	0	4	4	6	14	20	50	60	74	92	0.13
25	Paris green Oxalic acid	7 1	30	----	0	----	0	----	7	----	13	23	46	70	93	----	100	0.01
15	Paris green Oxalic acid	12 4	50	0	0	0	2	4	4	12	22	46	72	94	96	98	100	0.01
16	Paris green Oxalic acid	15 3	50	0	0	0	2	2	2	2	10	22	54	64	94	96	96	0.01
17	Paris green Oxalic acid	20 3	50	0	0	0	2	6	6	8	18	26	50	88	90	90	90	0.01

18	Paris green Oxalic acid	25 5	50	0	0	0	6	8	12	16	28	60	74	90	96	96	96	0.01
19	Paris green Oxalic acid	35 5	50	0	0	0	2	4	6	10	14	40	54	92	94	94	94	0.01

TABLE 2.—*Larvicidal effects of Paris green and lime partially adsorbed on charcoal.*

Test No.	Substance used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals.																Weight of larvicide.
				Minutes.								Hours.								
				15	30	45	60	75	90	105	120	2.5	3	4	5	6	24	48	72	
		Per cent.																		*g.*
24	Control (nothing)	----	50	0	0	0	0	0	0	0	0	0	0	0	2	2	2	----	----	----
95	Paris green Lime	0.1 0.5	50	0	0	0	0	0	0	0	2	20	58	80	88	94	100	----	----	0.1
94	Paris green Lime	0.8 0.3	50	0	0	0	0	0	0	0	2	2	4	20	52	52	100	----	----	0.1
28	Paris green Lime	3.0 1.0	29	----	0	----	3	----	22	----	38	65	79	93	95	----	100	----	----	0.13
39	Paris green Lime	3.0 1.0	50	0	0	0	0	0	14	22	44	68	76	86	94	94	98	----	----	0.13
81	Paris green Lime	3.0 1.0	50	0	0	0	0	14	30	80	92	98	100	100	100	100	100	----	----	0.1
27	Paris green Lime	4.0 2.0	30	----	0	----	0	----	30	----	57	77	87	97	97	----	100	----	----	----
26	Paris green Lime	7.0 1.0	30	----	0	----	0	----	3	----	20	23	51	77	90	----	100	----	----	0.01
29	Lime	10.0	50	0	2	2	2	2	2	2	2	2	2	2	2	2	4	4	10	0.13
23	Lime, plain	----	50	0	0	0	0	0	0	0	0	0	0	2	2	2	4	----	----	0.13

TABLE 3.—*Larvicidal effects of Paris green and borax partially adsorbed on charcoal.*

Test No.	Substance used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals.																	Weight of larvicide.
				Minutes.								Hours.									
				15	30	45	60	75	90	105	120	2.5	3	4	5	6	7	24	48	72	
			Per cent.																		g.
140	Control (nothing)	----	50	0	0	0	0	0	0	0	0	0	0	2	2	2	----	2	----	----	----
96	Paris green	0.5	50	0	0	0	0	0	0	0	0	0	0	6	30	38	42	94	----	----	0.1
	Borax	0.5																			
123	Paris green	0.5	50	0	2	4	6	6	6	6	12	14	18	34	44	58	62	96	----	----	0.665
	Borax	0.5																			
97	Paris green	0.8	50	0	0	0	0	0	2	2	2	2	4	10	24	48	70	96	----	----	0.1
	Borax	0.4																			
124	Paris green	0.8	50	0	0	0	0	0	0	0	0	8	8	36	46	50	66	94	----	----	0.665
	Borax	0.4																			
142	Paris green	0.8	50	0	0	0	0	0	0	0	0	0	8	16	21	----	----	92	----	----	0.1
	Borax	0.4																			
93	Paris green	0.8	50	0	0	0	0	2	4	4	6	12	18	28	54	60	----	100	----	----	0.1
	Sodium carbonate	0.3																			
166	Borax	2.0	50	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	----	----	0.1

TABLE 4.—*Larvicidal effects of Paris green, arsenic trioxide, and lime (or borax) partially adsorbed on charcoal.*

Test No.	Substance used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals.																	Weight of larvicide.
				Minutes.								Hours.									
				15	30	45	60	75	90	105	120	2.5	3	4	5	6	7	24	48	72	
		Per cent.																			*g.*
103	Control (nothing)	----	50	0	0	0	0	0	0	0	0	0	0	0	0	0	----	0	----	----	----
130	do.	----	50	0	0	0	0	0	0	0	0	0	0	0	0	0	----	8	----	----	----
63	Paris green Arsenic trioxide Lime	0.5 2.0 0.1	48	0	0	0	0	2	2	2	4	14	24	44	72	81	85	96	----	----	0.13
90	Paris green Arsenic trioxide Lime	0.5 0.5 0.5	50	0	0	0	0	2	2	12	20	38	56	80	90	96	96	100	----	----	0.1
110	Paris green Arsenic trioxide Borax	0.5 0.05 0.1	50	0	0	0	0	0	0	0	0	0	0	0	2	12	18	76	76	82	0.1
129	Paris green Arsenic trioxide Borax	0.05 0.05 0.1	50	0	0	0	0	0	0	0	0	0	0	0	2	6	24	94	----	----	0.665
134	Paris green Arsenic trioxide Borax	0.05 0.05 0.1	50	0	0	0	0	0	0	0	0	0	0	0	18	26	----	88	----	----	0.33
98	Paris green Arsenic trioxide Borax	0.3 0.3 0.3	50	0	0	0	0	0	0	0	0	0	6	32	42	58	68	96	----	----	0.1
125	Paris green Arsenic trioxide Borax	0.3 0.3 0.3	50	0	0	0	0	0	2	8	16	20	24	68	76	84	94	100	----	----	0.665

TABLE 4.—*Larvicidal effects of Paris green, arsenic trioxide, and lime (or borax) partially adsorbed on charcoal*—Ctd.

Test No.	Substance used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time period. Cumulative totals. Minutes. 15	30	45	60	75	90	105	120	Hours. 2.5	3	4	5	6	7	24	48	72	Weight of larvacide.
		Percent.																			*g.*
	Paris green	0.3																			
131	Arsenic trioxide	0.3	50	0	0	0	0	2	2	2	2	16	24	50	68	76	----	88	----	----	0.33
	Borax	0.3																			
	Paris green	0.3																			
143	Arsenic trioxide	0.3	50	0	0	0	0	2	2	2	2	4	8	30	60	----	----	96	----	----	0.1
	Borax	0.3																			
	Paris green	0.4																			
99	Arsenic trioxide	0.4	50	0	0	0	0	0	0	0	0	0	0	16	24	38	46	100	----	----	0.1
	Borax	0.4																			
	Paris green	0.4																			
147	Arsenic trioxide	0.4	50	0	0	0	2	2	2	2	2	2	6	38	46	----	----	96	----	----	0.1
	Borax	0.4																			
	Paris green	0.5																			
91	Arsenic trioxide	0.5	50	0	0	0	0	4	10	18	30	42	50	80	90	96	96	100	----	----	0.1
	Borax	0.5																			
	Paris green	0.7																			
100	Arsenic trioxide	0.7	50	0	0	0	0	0	0	0	0	0	8	58	66	96	96	100	----	----	0.1
	Borax	0.7																			
	Paris green	0.7																			
144	Arsenic trioxide	0.7	50	4	4	4	4	4	4	4	4	4	36	72	82	----	----	100	----	----	0.1
	Borax	0.7																			
	Paris green	1.0																			
102	Arsenic trioxide	1.0	50	0	0	0	0	0	0	0	0	0	0	40	90	90	92	96	----	----	0.1
	Borax	1.0																			

109	Paris green Arsenic trioxide Borax	0.1 0.1 0.2	50	0	0	0	0	0	0	0	0	0	0	2	6		14	78	80	88	0.1
128	Paris green Arsenic trioxide Borax	0.1 0.1 0.2	50	0	0	0	0	0	0	0	2	4	8	12	18	18	22	80	-----	-----	0.665
133	Paris green Arsenic trioxide Borax	0.1 0.1 0.1	50	0	0	0	0	0	0	0	0	0	2	10	18	32	-----	94	-----	-----	0.33
107	Paris green Arsenic trioxide Borax	0.2 0.2 0.2	50	0	0	0	0	0	0	0	0	0	4	10	22	42	54	96	-----	-----	0.1
108	Paris green Arsenic trioxide Borax	0.2 0.2 0.4	50	0	0	0	0	0	0	4	0	0	4	14	26	52	62	96	-----	-----	0.1
126	Paris green Arsenic trioxide Borax	0.2 0.2 0.2	50	0	0	0	0	0	0	4	4	8	16	40	68	68	70	96	-----	-----	0.665
127	Paris green Arsenic trioxide Borax	0.2 0.2 0.4	50	0	0	0	0	0	0	0	2	12	34	50	60	64	84	94	-----	-----	0.665
132	Paris green Arsenic trioxide Borax	0.2 0.2 0.2	50	0	0	0	0	0	0	0	0	8	12	28	48	66	-----	98	-----	-----	0.33
145	Paris green Arsenic trioxide Borax	0.2 0.2 0.2	50	0	0	0	0	0	0	0	0	0	0	6	6	-----	-----	46	-----	-----	0.1
149	Paris green Arsenic trioxide Borax	0.2 0.2 0.2	50	0	0	0	2	2	4	4	4	4	12	18	20	-----	-----	84	-----	-----	0.1

TABLE 5.—*Larvicidal effects of Paris green and other substances partially adsorbed on charcoal.*

Test No.	Substances used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals.																	Weight of larvicide.
				Minutes.								Hours.									
				15	30	45	60	75	90	105	120	2.5	3	4	5	6	7	24	48	72	
		Per cent.																			*g.*
119	Control (nothing)	-----	50	0	0	0	0	0	0	0	0	0	0	0	0	0	-----	0	-----	-----	-----
64	Paris green Arsenic trioxide Sodium carbonate	0.5 2.5 0.2	49	0	0	0	0	0	0	0	12	20	48	60	80	88	94	100	-----	-----	0.13
89	Paris green Arsenic trioxide Sodium carbonate	0.5 2.5 0.2	49	0	0	0	0	4	28	55	66	79	84	96	100	100	100	100	-----	-----	0.1
71	Paris green Arsenic trioxide Sodium carbonate	1.0 3.0 1.0	48	0	0	0	0	0	0	0	-----	-----	-----	-----	-----	-----	-----	83	-----	-----	0.13
72	Paris green Arsenic trioxide Sodium carbonate	1.0 3.0 2.0	49	0	0	0	0	0	0	2	2	4	8	14	18	30	-----	94	-----	-----	0.13
73	Paris green Arsenic trioxide Sodium carbonate	1.5 3.5 1.5	49	0	0	0	0	0	4	6	10	20	32	48	52	54	-----	100	-----	-----	
92	Paris green Arsenic pentoxide Borax	0.5 0.5 0.5	50	0	0	0	0	0	0	2	16	32	64	68	78	84	-----	96	-----	-----	0.1
65	Paris green Arsenic trioxide Lime Sodium carbonate	0.5 2.5 0.2 0.2	50	0	0	0	0	0	0	2	4	18	54	64	72	76	92	100	-----	-----	0.13

70	Paris green Arsenic trioxide Sodium bicarbonate	1.5 3.5 1.5	48	0	0	0	2	2	2	4	----	----	----	----	----	----	----	89	----	----	0.13
114	Paris green Rotenone hydrobromide	0.2 0.4	50	0	0	0	0	0	0	0	0	0	0	4	16	26	40	76	----	----	0.1
117	Paris green Arsenic trioxide Derris root Borax	0.05 0.1 0.1 0.3	50	0	0	0	0	0	0	0	0	2	2	2	2	6	6	22	----	----	0.1
118	Paris green Arsenic trioxide Derris root Borax	0.05 0.1 0.2 0.3	50	0	0	0	0	0	0	0	0	0	0	0	0	0	10	84	----	----	0.1

TABLE 6.—*Larvicidal effects of Paris green partially adsorbed on charcoal, when used against A. minimus fuliginosus, and philippinensis (three-fifths A. minimus).*

Test No.	Substances used.	Concentration.	Number of larvæ used.	Percentage of dead larvæ in time periods. Cumulative totals. Minutes. 15	30	45	60	75	90	105	120	Hours. 2.5	3	4	5	6	7	24	48	72	Weight of larvicide.
		Per cent.																			*g.*
187	Control (nothing)	----	50	0	0	0	0	0	0	0	0	0	0	2	2	2	2	4	8	----	----
177	Paris green Arsenic trioxide Lime	0.05 0.05 0.5	50	0	0	0	0	0	0	0	0	0	0	0	2	8	18	72	92	----	0.3
180	Paris green Lime	0.1 0.5	50	0	0	0	0	0	0	0	0	0	2	4	4	8	20	50	84	----	0.3
185	Paris green Arsenic trioxide Borax	0.1 0.1 0.2	50	0	0	0	0	0	0	0	0	0	0	6	16	16	30	54	98	----	0.3
182	Paris green Arsenic trioxide Borax	0.2 0.2 0.2	50	0	0	0	0	0	0	0	2	8	10	30	58	60	62	96	98	----	0.3
181	Paris green Borax	0.5 0.5	50	0	0	0	0	0	0	0	0	14	20	36	48	56	62	90	100	----	0.3
186	Paris green Arsenic trioxide Lime	0.5 0.5 0.5	50	0	0	0	0	0	0	0	4	4	4	26	42	58	70	100	----	----	0.3
179	Paris green Arsenic trioxide Borax	0.7 0.7 0.7	50	0	0	0	0	8	8	8	30	44	44	52	64	70	80	100	----	----	0.3
184	Paris green Lime	0.8 0.3	50	0	0	0	0	0	0	0	8	18	34	50	68	76	84	98	100	----	0.3
178	Paris green Lime	1.0 0.5	50	0	0	0	0	0	0	0	18	38	42	61	72	78	88	100	----	----	0.3

Combinations of Paris green and borax partially adsorbed on charcoal were not as effective as Paris green and lime.

Combinations of Paris green and arsenic trioxide partially adsorbed on charcoal in very low concentrations (much less than 1 per cent) were used with good effect in some tests.

Some tests were carried out with larvæ of different species; namely, *Anopheles minimus*, *A. fuliginosus*, and *A. philippinensis*. In these tests the larvæ of *A. minimus* were the first to succumb.

ILLUSTRATIONS

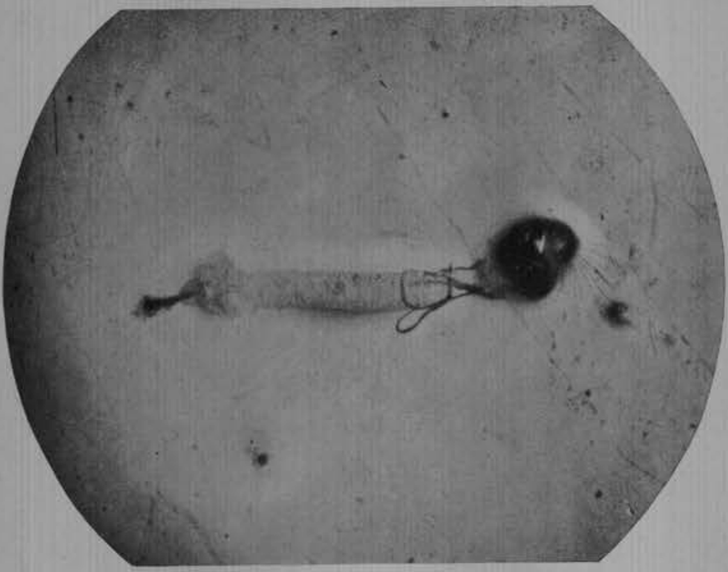
[The photographs show the gut of larva of *A. philippinensis* dissected out after feeding. The larva had begun to feed in a pan with 0.1 gram of larvicidal charcoal distributed evenly over a surface area of 532 square centimeters. The photographs show the gradual filling of the gut in a period of ninety minutes.]

PLATE 1

FIG. 1. After feeding ten minutes.
2. After feeding fifteen minutes.

PLATE 2

FIG. 1. After feeding thirty minutes.
2. After feeding sixty minutes.
3. After feeding ninety minutes.



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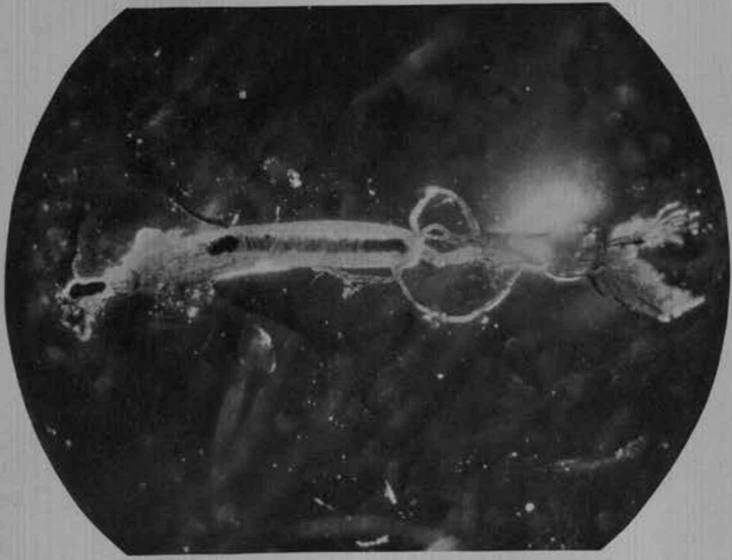

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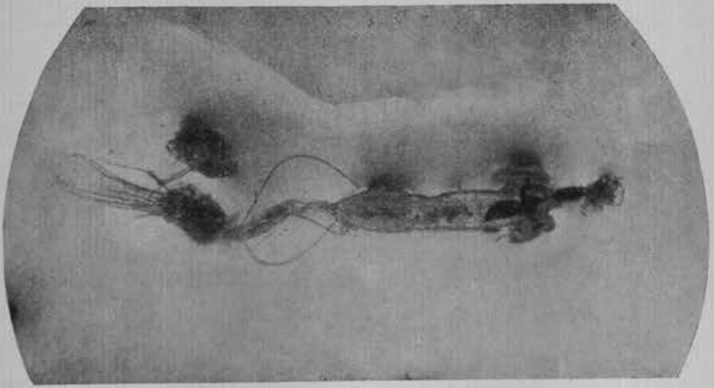
PLATE 1.



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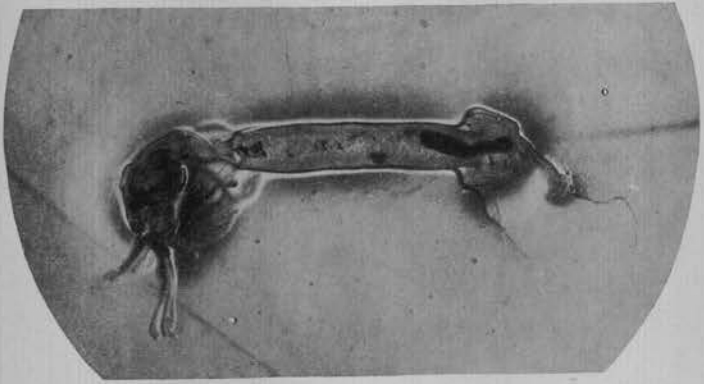

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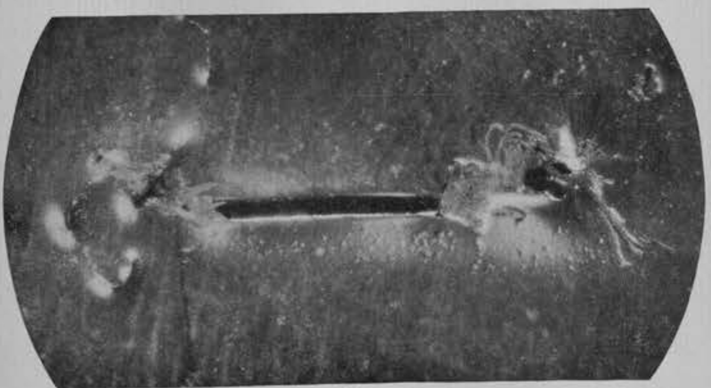

3

PLATE 2.

MORPHOLOGICAL AND CHEMICAL STUDIES ON THE SEEDS OF ERYTHRINA VARIEGATA VAR. ORIENTALIS (LINNÆUS) MERRILL[1]

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SIX PLATES

Erythrina variegata var. *orientalis* (Linn.) Merr., locally known as *dap-dap,* is a deciduous plant occurring along the seashores of the Philippines; frequently, however, it is cultivated. This plant is one of the four species of *Erythrina* so far found in this country.

Plants of the genus *Erythrina* have been shown to contain alkaloidal constituents of varying physiological effects. For example, Bochefontaine and Rey[2] found the aqueous extract of the bark of *E. corallodendron* Linn. to have a paralyzing action on the central nervous system, due to erythrine, an alkaloid contained in the plant. Greshoff[3] also isolated erythrine from *E.* (*Stenotropis*) *berteroi* Hassk. and according to Plugge[4] this alkaloid is the active constituent of the plant. From the seeds of *E. hypaphorus* Boerl., Greshoff[5] and Van Romburg[6] obtained hypaphorine, an alkaloid which produces tetanus in frogs.[7] De

[1] This plant is also called *Erythrina indica* Lam. The botanical name adopted in this paper is in accord with the interpretation of Merrill in his classical work, An Interpretation of Rumphius' Herbarium Amboinense (1917) 276.

[2] Comptes rendus 92 (1881) 733.

[3] Meded. uit 's Lands Plant. 7 (1890) 29.

[4] Arch. f. exp. Path. u. Phar. 38 (1893) 46.

[5] Meded. uit 's Lands Plant. 25 (1898) 54.

[6] Proc. K. Akad. Weten. Amst. 13 (1911) 1177.

[7] Lewin, L., Traité de Toxicologie. Paris (1903) 646. (A translation from a German edition by G. Pouchet.)

line of meeting of the cotyledons on the concave, or ventral, side (Plate 1, figs. 6 and 7).

Microscopic structure.—The seed in transverse section is broadly ovate in outline. In the upper part of the broader side of the section there is a slight wavy depression with a very small slit at the middle region. This depression corresponds to the hilum, while the minute slit to the cross section of the tiny groove extends along the middle portion of the hilum toward the raphe. Apparently there is only one seed coat with varying thickness from 0.6 to 0.9 millimeter. It is thin toward the dorsal side and becomes progressively thicker toward the hilum. In the case of the pea, according to Smith,[14] there are two seed coats developed, respectively, from the two integuments; the inner seed coat is somewhat thicker and heavier than the outer, and the two are more or less firmly united. This may also be the case in the seed coats of the dap-dap, where the apparent single seed coat may consist of two coats derived from the two integuments which are firmly united. In view of the fact that this question cannot be settled without going into the study of the origin and development of the dap-dap seed coat or coats, no definite statement regarding the number of seed coats in the dap-dap seed can be given until a further morphological study is undertaken. This omission does not, however, affect the main purpose of this morphological work, which is simply to provide a description of the structure of the dap-dap seed that can be used as a basis for distinguishing it from other seeds. There are four more or less distinct regions of the seed coat or coats. The outermost region is the epidermis. It consists of radially elongated hyaline cells measuring from 0.25 to 0.30 millimeter in length and about 0.08 millimeter in diameter. Their cell walls are composed of cellulose traversed by pits and are strongly and irregularly thickened. The cavities of these epidermal cells are narrow toward the upper part and wide toward the base. At this part the lumen is usually irregular, wavy or jagged in outline. Plate 2, fig. 12, is a semidiagrammatic representation of a cross section through the seed coat or coats. In the surface view the epidermal cells are polygonal in outline, with very thick and pitted cell walls (Plate 2, fig. 13). The second or middle region is a wide parenchymatous region about 0.45 millimeter in thickness. To-

[14] A Textbook of General Botany, rev. ed. (1928) 437-8.

ward the outer part it is limited by the palisade epidermal cells and toward the inner side by greatly obliterated parenchyma cells. The parenchymatous region may be subdivided into two parts; namely, the hypoderma and the parenchyma. The hypoderma is composed of one or more layers of loosely arranged and radially elongated cells about 0.024 millimeter wide and 0.07 millimeter long. These cells are slightly constricted about the middle, and the upper end is wider than the lower end so that they simulate the shape of an inverted capstan. They are provided with numerous intercellular spaces and their walls are somewhat thick and not lignified. The parenchyma consists of ten to fifteen layers of thin- or thick-walled, radially elliptic or tangentially elongated cells. The two or three outer layers are radially elongated and those toward the inner side are elliptic or tangentially elongated. These cells are also supplied with intercellular spaces, and so are somewhat loosely arranged. They contain a reddish brown substance or pigment. The third region is relatively narrow. It is from 0.03 to 0.045 millimeter in thickness and is built up of a compact obliterated parenchyma. The fourth region, which is the innermost one, is about 0.15 millimeter in thickness. It also consists of several layers of tangentially obliterated parenchyma cells containing a reddish brown substance. In this region, however, the parenchyma cells are not so greatly compressed as those of the third region.

The structure of the section of the seed coat or coats at the region of the hilum is somewhat complicated. The epidermis consists of a double row of palisade cells, and in the outer part of this epidermis there are two or three layers of small radially or obliquely compressed cells with thin, white, and slightly suberized cell walls. The epidermis is interrupted at the middle part by a small slit, which represents the transverse section of the small narrow groove extended along the middle region of the hilum. Below this slit as illustrated on Plate 2, fig. 9, there is a flask-shaped group of lignified porous cells of polygonal, rectangular, or irregular outline. These porous cells are called tracheids by Greenish [15] and according to him their function is not accurately known. They are surrounded by three layers of elongated, thick-walled, somewhat flattened cells (Plate 2, fig. 12). At the inner part of the epidermis covering the

[15] The Microscopical Examination of Foods and Drugs. 2d ed. (1910) 234.

hilum there is a region of stone cells with slightly lignified thick and pitted walls. This region is bounded toward the inner part by an extensive group of thick-walled, pitted, and loosely arranged cells known as modified hypodermal cells. These cells have wavy or irregular outlines with large intercellular spaces filled with a brown substance. Their walls are not lignified. In the inner part the modified hypoderma is limited by obliterated parenchyma cells traversed by conducting tissue.

In the longitudinal section through the hilum the tracheid cells form an elongated region parallel to the epidermis and extending from near the micropyle to the raphe. Toward the micropyle this region is bounded by a group of short sclerenchyma cells or stone cells, at the other end by the raphe; in the inner part by the modified hypoderma and obliterated parenchyma cells, and toward the periphery by the epidermis. At the other side of the raphe, just below the epidermis corresponding to the elevated region, there is a group of slightly lignified stone cells, with thick and pitted walls. The micropyle appears as a small opening through the epidermis, bordered by short sclerenchyma cells and by loosely arranged, thick-walled, and irregularly shaped cells. The walls of these cells are not lignified and they are richly supplied with intercellular spaces.

The cotyledons in transverse section are plano-convex in outline. They are composed chiefly of thin-walled parenchyma cells filled with minute protein granules, oil globules, a very small amount of tiny starch grains, and some solitary or clustered monoclinic calcium oxalate crystals. The epidermis consists of small radially elongated parenchyma cells filled mostly with protein granules and some globules of fixed oils. In surface section these epidermal cells are polygonal in outline (Plate 1, fig. 14, and Plate 3, fig. 16). In the inner part of the epidermis there are one or two layers of radially elongated cells arranged somewhat in palisade form. These cells have thin walls and are filled like the epidermal cells with minute protein granules, a few starch grains, some globules of fixed oil, and occasionally with some calcium oxalate crystals. They are interspersed with small intercellular spaces. Plate 3, fig. 16, represents a segment prepared from the convex, or dorsal, side of a cotyledon, showing the epidermis and the palisade cells; fig. 17, on the same plate, shows a segment of a thin section through the middle portion of the cotyledon. This segment exhibits the characters of the parenchyma cells of the central region of the

cotyledon. They are polygonal in outline with slightly wavy cell walls and large intercellular spaces. These parenchyma cells like the palisade cells are richly supplied with protein granules, oil globules, and small starch grains in clusters of two, three, or four grains. Some calcium oxalate crystals are frequently found in the parenchyma cells of the middle region.

The seeds subjected to 2 per cent sodium hydroxide and Schultz's maceration process, respectively, exhibit the characteristic type of cells indicated on Plate 3, figs. 19 to 30. The palisade cells of the seed coat are observed singly or in groups; the peculiar capstan-shaped hypodermal cells are found here and there in various positions; the parenchyma cells from the seed coat are distinctly different from those of the cotyledons, because they possess an irregular outline and are somewhat flattened; the tracheid cells and stone cells display great diversity in shape and size. The tracheids are readily distinguished from the other cells because of their greatly perforated walls, while the stone cells are identified by their thick, lignified, and pitted cell walls. The cells from the modified hypoderma are also conspicuous. They also have thick and pitted walls, but not lignified. Their general appearance is very much like those of the stone cells. The epidermal cells of the cotyledon appear singly or in groups and are readily recognized from their size and elongated shape. They generally appear empty, but sometimes their content is preserved. The parenchyma cells from the middle region of the cotyledons are more or less rounded, usually empty, and with some slight protuberances bulging from the surface.

Starch grains.—The starch grains of the dap-dap seed are comparatively very small. They measure only about 0.005 millimeter in diameter. These starch grains are found either alone or in clusters of two, three, or four grains. They are ellipsoidal, elliptic, or ovate in outline, with very prominent, circular or elliptic hilum. On account of this prominent hilum the starch grains of the dap-dap appear very similar to the general outline of the red blood corpuscles of animals or man (Plate 3, figs. 18 and 19).

Protein granules.—The protein granules of the dap-dap seed are very small. They measure about 0.001 millimeter in diameter. Their structure is not very conspicuous. They are more or less rounded and in aggregated form.

Oil globules.—The oil globules are scattered throughout the cell cavities in the embryo, particularly in the cotyledons. They intermingle with the starch grains and protein granules. These globules are conspicuous even in unstained sections. They consist of minute globules ranging from 0.007 to 0.009 millimeter in diameter. When the sections are treated with freshly prepared alkana tincture they readily absorb the stain and become pinkish or reddish (Plate 3, fig. 19).

Crystals of calcium oxalate.—The cells of the cotyledons are frequently loaded with one or more calcium oxalate crystals in monoclinic or prismatic forms. These crystals are often found isolated or in clusters of two or more crystals. When they are in clusters of three or more crystals, they are often arranged in a more or less zigzag form. The individual crystal measures from 0.0065 to 0.011 millimeter in diameter and from 0.018 to 0.04 millimeter in length. They are especially abundant in the middle region of the cotyledons, but are absent from the seed coats (Plate 3, figs. 16 and 25).

Microchemical tests and localization of the alkaloid.—This brief microchemical investigation was undertaken as a supplement to the above study in order to determine the distribution of the alkaloid in the seed. The seed coats and the different regions or parts of the embryo were examined. Free-hand and microtome sections were prepared and treated with the reagents indicated above. The reagents were applied to the sections either directly or indirectly. The direct application of the reagent consists of first mounting the section in a very small amount of water and then treating with the reagent. In the indirect method the sections were first macerated for about twelve hours with a very dilute aqueous solution of hydrochloric acid before adding the reagents. Observations were made at short intervals for a period of an hour and after keeping the sections in a Frigidaire overnight. Rapid reactions with the alkaloidal reagents were obtained by heating the slides slightly on top of a paraffin oven for a couple of minutes. The tests were repeated several times until definite results were obtained. The results obtained from the tests of the sections supposed to contain alkaloid were compared with the results of the tests made on the sections freed from alkaloid, and from the results obtained by using a dilute acidulated solution of the pure alkaloid. The precipitates produced by the different reagents applied to the sections containing alkaloid are very similar to those formed when the dilute acidulated solution of

the pure isolated alkaloid was treated with the same reagents. The precipitates produced on the sections treated with picric acid, ferric gold chloride, and Wagner's reagents were rather slight and not very conspicuous, but those formed by the action of the same reagents on the dilute acidulated solution of isolated alkaloid were more pronounced and of granular or amorphous character. The most effective of the reagents employed in these experiments were the gold chloride solution and Mayer's reagent. In both tests a rapid reaction and a larger amount of precipitate were observed. However, the precipitate produced by the gold chloride is more conspicuous and characteristic, for it is granular and curdy and of a pinkish or purplish color at the beginning, gradually becoming black (Plate 3, fig. 31). The precipitate produced by Mayer's reagent was similar to those of the other reagents, but more copious and, moreover, the individual granules were larger.

From the results of these tests it appeared that the alkaloid is present in the different parts of the embryo, particularly in the cotyledon, and absent in the seed coats.

CHEMICAL STUDY

Preparation of the material.—The mature seeds were ground to a moderately coarse powder, and aliquot portions were used for the different determinations. In order to express the analytical data on a moisture-free basis, two portions of the powdered seeds were heated in an oven at 100° C. to constant weight and the percentage of moisture determined in the usual manner.

Preliminary analysis.—A sample (10 grams) was boiled with 95 per cent alcohol (reflux) and the alcoholic filtrate was evaporated on a water bath. A portion of the residual extract was treated with acidified water and the acid solution tested with the usual alkaloidal reagents, whereupon copious precipitates were noted. The remaining extract was first treated with ether and then with water. It was found that the alkaloid is soluble in water, but insoluble in ether.

Another 10-gram sample of powdered seeds was boiled with 25 per cent alcohol and filtered. The filtrate was concentrated and tested for the presence of saponaceous glucosides with the following results:

(*a*) When treated with emulsin, or hydrolyzed with hydrochloric acid and then neutralized with carbonate, it reduced Fehling's solution.

(*b*) It gave a blood red color with concentrated sulphuric acid.

(*c*) It produced a Turnbull's blue color with an aqueous solution of potassium ferricyanide containing ferric chloride.

(*d*) It emulsified a fixed oil.

(*e*) It formed precipitates with lead acetate and barium hydroxide solutions.

Guignard's test [16] for the detection of cyanophoric glucosides applied to a 5-gram sample gave a negative result.

A portion (10 grams) of the sample was extracted successively in a Soxhlet apparatus with various solvents, and the following amounts of residue, dried at 100° C., were obtained:

Extract.	Per cent.
Ether	15.91
Petroleum ether	0.60
Chloroform	1.07
Ethyl acetate	1.31
Ethyl alcohol	4.38
Total	23.27

The ether extract was found to consist mostly of oil, while the alcoholic extract was syrupy and contained the alkaloid. The other extracts were too small for further examination.

Proximate chemical analysis.—This was determined according to the method proposed by Waksman and Stevens [17] and the result obtained is shown in Table 1.

TABLE 1.—*Proximate chemical composition of dap-dap seeds.*

Constituent.	Per cent.[a]
Ether-soluble portion	15.91
Alcohol-soluble portion	0.54
Cold-water soluble organic matter	21.07
Hot-water soluble organic matter	3.42
Hemicelluloses	13.74
Celluloses	20.37
Lignin	14.63
Crude protein	1.01
Ash	5.01
Total	95.70

[a] Calculated on moisture-free basis.

[16] Haas, P., and T. G. Hill, An Introduction to the Chemistry of Plant Products 1 (1921) 17.

[17] Ind. Eng. Chem. Analytical Ed. 2 (1930) 167.

Isolation of the alkaloid.—For the separation of the alkaloid from dap-dap seeds, several methods were tried. Since the alkaloid easily forms crystalline salts with either hydrochloric acid or hydrobromic acid, attempts were first made to separate the free alkaloid in the form of its salt and then regenerate it by dissolving the alkaloidal salt in water, adding to the solution an excess of sodium carbonate, drying the mixture on the water bath, and extracting the alkaloid with absolute alcohol. It was found that the alkaloid obtained in this manner is always contaminated with traces of sodium salts.

The methods for the preparation of hypaphorine,[18] as given by Greshoff, from *Erythrina hypaphorus* Boerl. were next tried, but these also failed to give satisfactory results. The procedure finally adopted consisted in precipitating the alkaloid from its aqueous solution with phosphomolybdic acid (Sonnenchein's reagent), mixing the precipitate with sodium carbonate, and after drying the mixture, extracting the liberated alkaloid with absolute alcohol. For this purpose, one kilogram of the ground seeds was first extracted repeatedly with ether in order to remove the oil. The combined ethereal extracts were distilled and the oil reserved for further analysis. The powdered seeds from the ether extraction were allowed to dry at room temperature and percolated with ordinary alcohol. The percolate was subjected to distillation under reduced pressure, and the alcohol was completely removed by heating the concentrated solution on the water bath. The syrupy extract obtained was dissolved in water and filtered. Phosphomolybdic acid solution was then added to the aqueous liquid until no further precipitate was formed. The precipitate was collected, washed with water containing a little of the phosphomolybdic acid solution, and the moist precipitate was mixed with sodium carbonate and then dried on a water bath. The mixture was then treated repeatedly with absolute alcohol, boiled (reflux), and filtered. The combined alcoholic filtrate was concentrated by distillation and the alkaloid allowed to crystallize. For the purification of the impure alkaloid the colored crystals were redissolved in absolute alcohol, a small amount of animal charcoal added, and the solution filtered. Upon evaporating the filtrate, white crys-

[18] The writers desire to express their thanks to Dr. Otto Schöbl, of the Bureau of Science, for his kindness in translating from Dutch into English the directions for the preparation of hypaphorine as given in Meded. uit 's Lands Plant. 25 (1898) 56.

tals of the alkaloid were obtained. Photomicrographs of the alkaloid, as well as its salts, crystallized from different solvents, are shown in Plates 4 to 6, figs. 32 to 36. The free alkaloid is very soluble in water, fairly soluble in ethyl and methyl alcohols, but insoluble in ether and petroleum ether. The alkaloid reduces potassium permanganate and ferric chloride at low temperature and gives an intense violet coloration on the addition of glyoxylic and sulphuric acids. When heated with aqueous potassium hydroxide, the fishy odor of trimethyl amine was noted. It begins to melt at 238° C., changing into a brown substance, thereby obscuring the exact melting point. In general, these properties are those of hypaphorine,[19] which was isolated by Greshoff[20] from *Erythrina hypaphorus* Boerl. The identity of this alkaloid was further confirmed by the result of the elementary microanalysis of the anhydrous alkaloid.[21]

TABLE 2.—*Elementary microanalysis of the anhydrous alkaloid.*

	Carbon.	Hydrogen.	Nitrogen.
	Per cent.	*Per cent.*	*Per cent.*
Calculated for $C_{14}H_{18}N_2O_2$ (hypaphorine)	68.24	7.38	11.37
Found:			
Analysis I	68.30	7.30	11.40
Analysis II	67.90	7.76	11.40

Physiological effect of the alkaloid.—An aqueous solution of the alkaloid isolated, when injected subcutaneously into a guinea pig at intervals and in varying doses up to 0.1 gram of the substance, did not produce any apparent toxic symptom. According to Plugge,[22] hypaphorine is physiologically a very peculiar substance. From several tests made by him, using rabbits, cavies, mice, pigeons, frogs, and fishes, the substance was found poisonous only to the frog. In this amphibian, he observed that different doses of this alkaloid up to 5 milligrams produced only symptoms of excitation, but when the amount was increased from 12 to 75 milligrams, a still higher excitability and finally a strong tetanus was noticed two and one-half to twenty-four

[19] Van Romburgh, P., and G. Barger, Trans. Chem. Soc. 99 (1911) 2068.

[20] Loc. cit.

[21] The writers are indebted to Dr. Alfredo Santos, of the School of Pharmacy, University of the Philippines, for the microanalysis of the alkaloid.

[22] Tijdschr. v. Geneesk. 1 (1893) 933. From Meded. uit 's Lands Plant. 25 (1898) 61.

hours after administration. In the case of the rabbit, he found that a considerable amount of hypaphorine injected subcutaneously was eliminated as such in the urine.

The hydrochloride and hydrobromide salts of the alkaloid are colorless with melting points of 227° C. and 225° C., respectively. The hydrochloride salt occurs in clusters of featherlike crystals and the hydrobromide in radiating needlelike crystals. They also reduced potassium permanganate and ferric chloride solutions at low temperatures.

Quantitative estimation of the alkaloid.—A sample consisting of 50 grams of the air-dried, ground seeds was treated with ether and then with ordinary alcohol in the same manner as in the extraction of the alkaloid already described, and from the alcoholic extract the alkaloid was removed in the form of its hydrobromide salt. There was obtained an amount of hydrobromide (1.5005 grams) corresponding to 2.505 per cent of the free alkaloid computed from the moisture-free sample.

The fatty oil.—The viscous yellow oil of dap-dap seed, obtained by extraction with ether, has a peculiar and characteristic odor and was found to give the following physical constants:

Specific gravity at 30° C.	0.9071
Refractive index at 30° C.	1.4625
Saponification number	240.12
Iodine number	25.37
Acetyl value	13.02

Isolation of the saponin.—After treatment with 95 per cent alcohol to separate the alkaloid, the powdered residue was heated moderately with a sufficient amount of water and the resulting mixture was strained through muslin. The brown liquid was set aside overnight to allow the fine particles of powder to settle out. The clear aqueous liquid was then decanted and filtered. The filtrate was precipitated by basic lead acetate and the precipitate collected and washed well with water. It was then suspended in water and decomposed by means of hydrogen sulphide. The lead sulphide precipitate was removed by filtration, and bubbles of air were passed through the aqueous filtrate to remove the excess hydrogen sulphide. The liquid was then evaporated to drynes in a vacuum oven, dissolved in methyl alcohol, and the solution filtered. This alcoholic solution was concentrated to a small volume, precipitated with ether, and the ether-alcohol mixture allowed to stand over the saponin for twenty-four hours to allow any resinous substances, carried down by

the precipitated saponin, to redissolve. A brown precipitate was produced which was filtered and dried in vacuum. The product obtained gave positive results with the usual tests for saponin.

SUMMARY

The dap-dap seed is exalbuminous, and kidney shaped with a fairly large elliptical or oblong-ovate hilum at the concave side. The surface is smooth and shiny and of a reddish brown to dark chocolate color.

The seed coat or coats consist of (*a*) radially elongated epidermal cells arranged in the form of palisade, (*b*) hypoderma, (*c*) middle parenchyma, (*d*) greatly obliterated parenchyma, and (*e*) inner obliterated parenchyma.

The transverse section through the hilum is characterized by (*a*) a slit leading to the group of flask-shaped tracheid cells, (*b*) radially or obliquely elongated or flattened, slightly suberized parenchyma cells, (*c*) double rows of palisade epidermal cells, (*d*) a region of short sclerenchyma cells, (*e*) modified hypoderma, and (*f*) obliterated parenchyma.

In the longitudinal section through the hilum the following may be noted: (*a*) Raphe, (*b*) micropyle, (*c*) double rows of palisade epidermal cells, (*d*) stone cells, (*e*) modified hypoderma, and (*f*) tracheids.

The embryo is large and consists of two thick kidney-shaped cotyledons, the epicotyl, which bears two minute immature leaves, and the hypocotyl.

The cotyledons in transverse section are characterized by (*a*) the small radially elongated epidermal cells heavily loaded with protein granules and a few oil globules; (*b*) large intercellular spaces, palisade and parenchyma cells richly supplied with protein granules, oil globules, monoclinic calcium oxalate crystals, and minute rounded or ellipsoidal starch grains with large circular hilum.

The alkaloid of dap-dap seed is located in the embryo, especially in the cotyledons. Gold chloride solution produces characteristic granular and curdy precipitate with this alkaloid, while Mayer's reagent gives an amorphous noncrystalline precipitate.

The proximate chemical composition of the seed and the amounts of extracts from various solvents were determined.

The important plant constituents obtained from the seed are, an alkaloid, a fatty oil, and a saponaceous glucoside.

The alkaloid isolated from the seed occurs in colorless crystals and has reducing properties. It also responds to the Hopkins-Cole reaction for the presence of the tryptophane group. From the result of the elementary analysis and from its properties, the alkaloid is identical with hypaphorine ($C_{14}H_{18}N_2O_2$), which was obtained by Gresshoff from *Erythrina hypaphorus* Boerl.

The alkaloid easily forms crystalline, colorless salts with hydrochloride and hydrobromic acids. The hydrochloride is obtained in a cluster of featherlike crystals, and the hydrobromide in radiating needlelike crystals. These salts have also reducing properties.

Computed on a moisture-free basis, the seed contains 15.91 per cent of fixed oil and 2.504 per cent of the alkaloid.

The fatty oil of the seed is a yellow, viscous liquid and has a peculiar and characteristic odor. Some of the physical constants of the oil were determined.

No apparent toxic symptom was observed in a guinea pig when varying doses of the aqueous solution of the alkaloid were injected subcutaneously.

A convenient method was found for separating saponin from the seed.

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ILLUSTRATIONS

[All of the plates illustrate *Erythrina variegata* var. *orientalis* (Linn.) Merr. All microscopic drawings were traced by Mr. J. V. Santos under the direction of the authors; figures 1 to 3 by Mr. R. Aguilar; figure 2 traced from volume 1, plate 217, of the Flora de Filipinas by Blanco, and figures 4 to 7 by W. Garcia.]

PLATE 1

FIG. 1. A habit sketch of the terminal portion of the branch showing the character and arrangement of leaves; × 0.4.

2. An inflorescence showing the general features of the flowers; × 0.4.
3. A single mature fruit. × 0.4.
4. A lateral view of a seed, *hi*, hilum; × 1.5.
5. Ventral view of a seed showing *hi*, hilum; *m*, micropyle; × 1.5.
6. A median longitudinal section through the hilum passing between the cotyledons; *hi*, hilum; *hy*, hypocotyl; *ep*, epicotyl; *c*, cotyledon; *sco*, seed coats; × 1.5.
7. A transverse section of the seed through the hilum; *hi*, hilum; *sco*, seed coats; × 1.5.
8. A diagrammatic sketch of a longitudinal section through the hilum of the seed coats; *e*, epidermis; *tr*, tracheids; *ra*, raphe; *mhd*, modified hypoderma; *m*, micropyle; *sc*, stone cells; *hp*, hypoderma; p^1 and p^2, obliterated parenchyma; *v*, vessels; × 7.

PLATE 2

FIG. 9. A diagrammatic sketch of a transverse section of the seed coats through the hilum; *e*, epidermis; *sp*, suberized parenchyma; *sc*, stone cells; *p*, parenchyma; *tr*, tracheids; *op*, obliterated parenchyma; × 24.

10. A detailed drawing of a small segment from a transverse section through the hilum showing, *mhd*, modified hypoderma; *op*, obliterated parenchyma; *tr*, tracheid; × 450.
11. A portion of a transverse section through the outer region of the seed coat of the hilum; *sp*, suberized parenchyma; *e*, epidermis, *sc*, stone cells; × 165.
12. A semidiagrammatic transverse section of the seed coat from the lateral side of the seed; *ep*, epidermis; *hd*, hypoderma; *p*, parenchyma; op^1 and op^2, obliterated parenchyma; × 55.
13. A small portion of a surface view of the epidermis showing the character of the epidermal cells; × 450.
14. A surface view of a segment of the epidermis of the cotyledon; × 450.
15. A detailed drawing of a segment of the transverse section through the epidermis and hypoderma; *cu*, cuticle; *e*, epidermal cells; *hd*, hypoderma; *is*, intercellular space; × 210.

PLATE 3

FIG. 16. A detailed drawing of a segment of the transverse section through the peripheral part of a cotyledon; *e*, epidermis; *pal*, palisade; *co*, calcium oxalate crystals; × 450.

17. A portion of a transverse section of the cotyledon taken from the middle region; *is*, intercellular space; × 210.
18. A group of starch grains highly magnified; × 700.
19. A parenchyma cell from a transverse section of a cotyledon highly magnified; *og*, oil globules; *sg*, starch grain; *pg*, protein granules; × 700.
20. A group of isolated hypodermal cells; × 210.
21. A group of isolated epidermal cells; × 210.
22. Another group of hypodermal cells drawn from the macerated section of the seed coat by a solution of sodium hydroxide; × 210.
23. A group of isolated stone cells from the seed coat near the hilum; × 210.
24. A group of modified hypodermal cells or parenchyma with thick and not lignified cell walls; × 210.
25. A group of isolated calcium oxalate crystals; × 450.
26. A group of parenchyma cells from the seed coat; × 210.
27. Another group of parenchyma cells from the seed coat isolated by the application of sodium hydroxide maceration process; × 210.
28. Isolated tracheid cells showing their greatly perforated cell walls; × 210.
29. Isolated epidermal cells of the cotyledon; × 210.
30. Parenchyma cells from the macerated section of the cotyledon by sodium hydroxide solution; × 210.
31. A parenchyma cell from the transverse section of the cotyledon with alkaloidal precipitate of gold chloride; × 450.

PLATE 4

FIG. 32. Featherlike crystals of the alkaloid hydrochloride.

33. Radiating needlelike crystals of the alkaloid hydrobromide.

PLATE 5

FIG. 34. Crystals of the alkaloid obtained by slow crystallization from methyl alcohol solution.

35. Alkaloid crystals from ethyl alcohol solution.

PLATE 6

FIG. 36. Crystals of the alkaloid obtained by slow evaporation of an aqueous solution on a microscopic slide.

37. A photograph of a group of seeds.

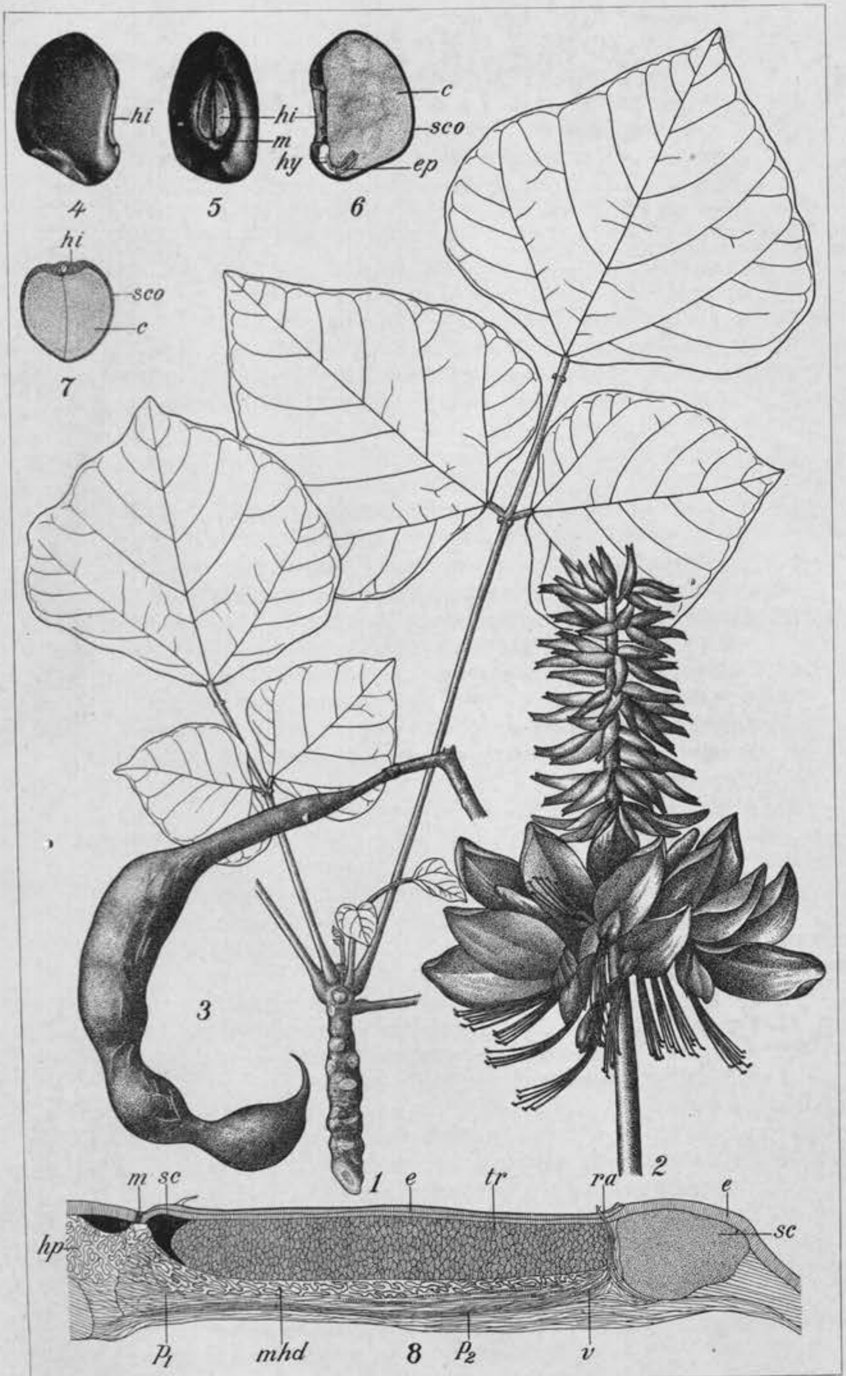

PLATE 1.

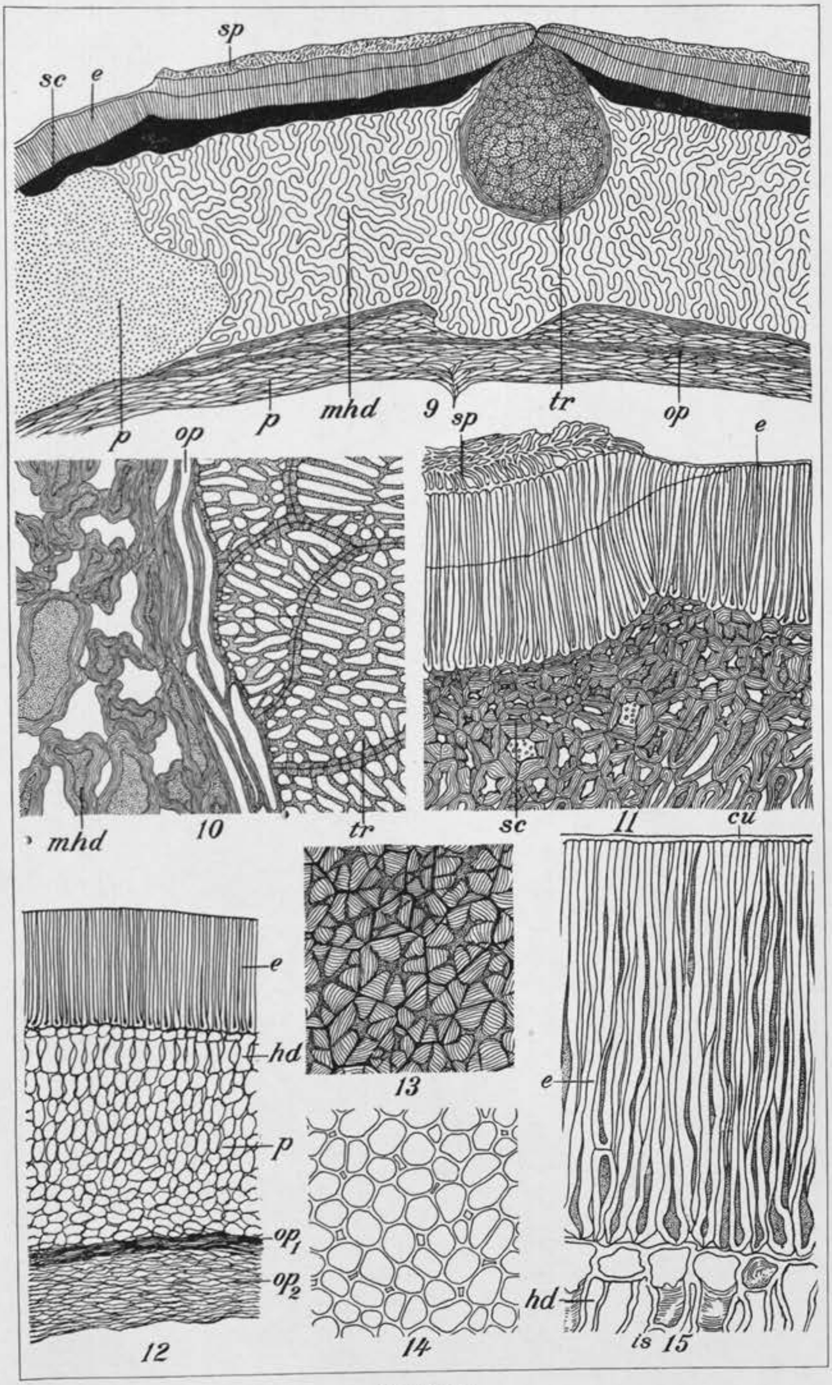
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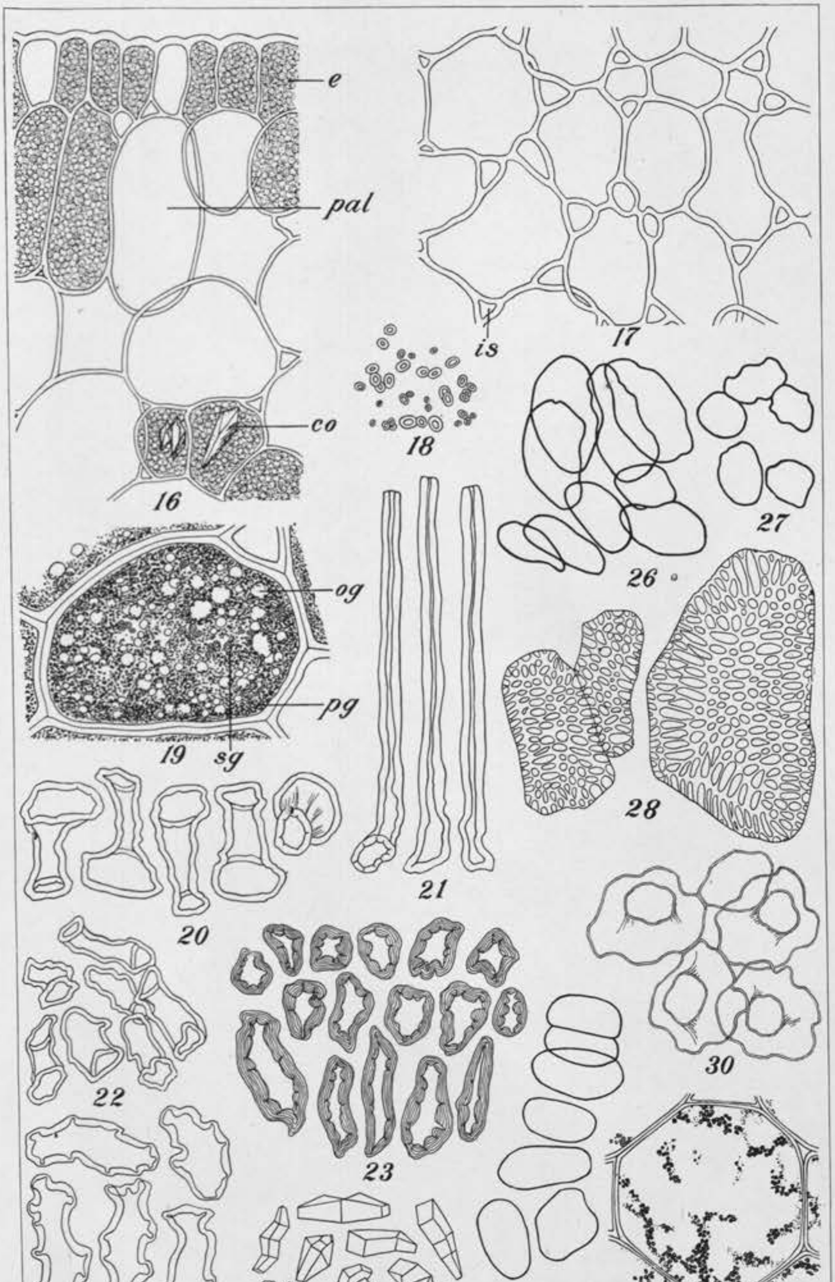
PLATE 2.



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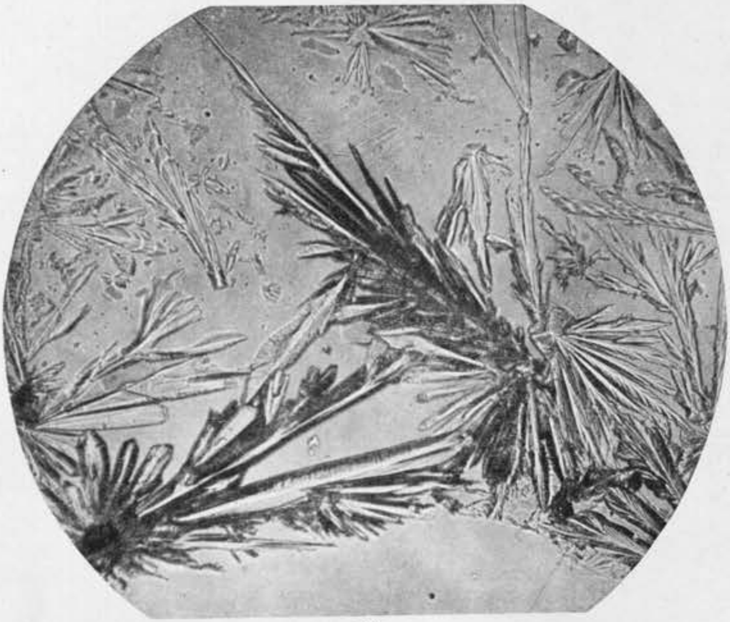

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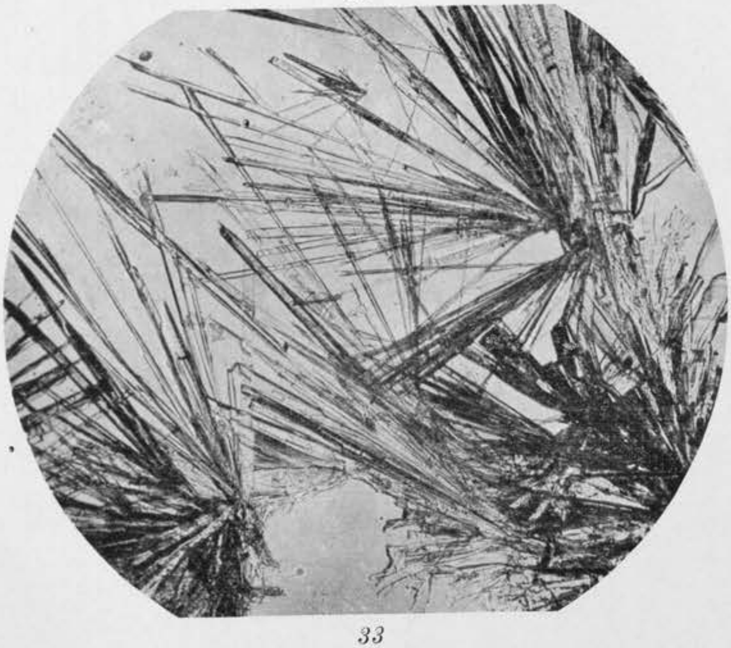

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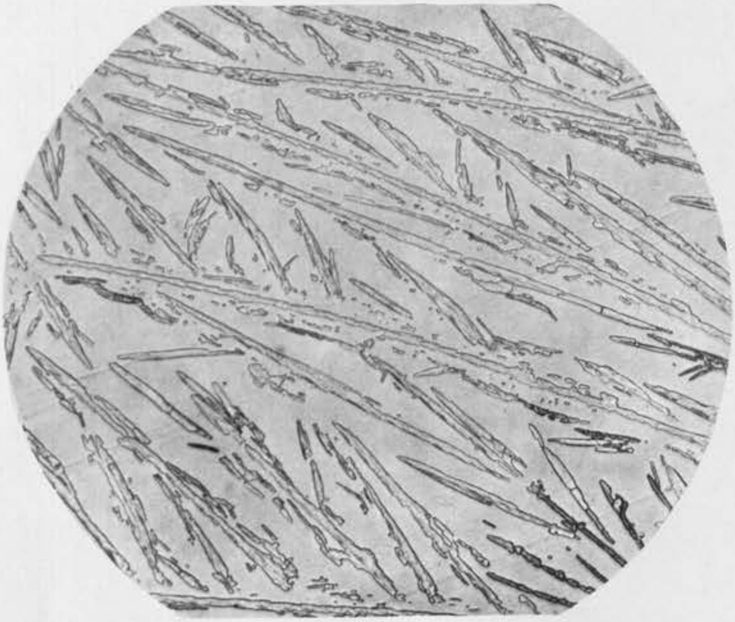
PLATE 4.



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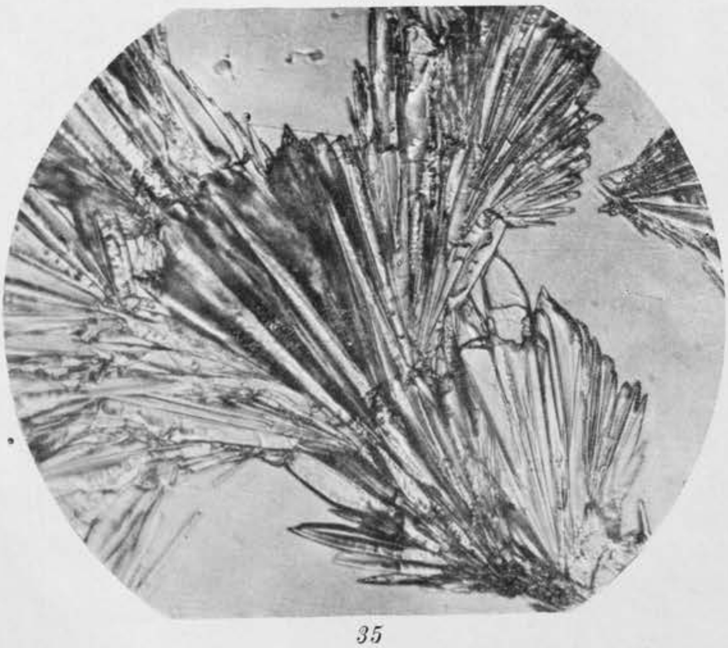

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PLATE 5.

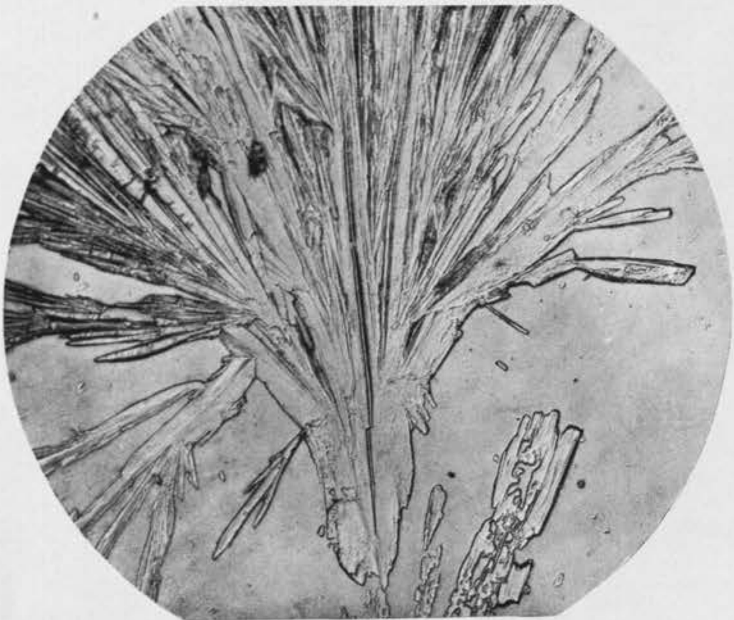

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PLATE 6.

OBSIDIANITES IN THE PHILIPPINE ISLANDS [1]

By T. HODGE-SMITH

Contribution from the Australian Museum, Sydney

TWO PLATES

Mr. F. W. McCaw, of Manila, Philippine Islands, presented thirteen examples of these interesting objects to the Australian Museum, Sydney, New South Wales, Australia, with a request that an examination be carried out, and a comparison made with the australite variety of obsidianite. Mr. McCaw kindly lent three large specimens to assist in such an investigation, and these notes are placed on record in accordance with his request.

The sixteen specimens all come from the Sitio of Pugad Baboy, Municipality of Polo, Bulacan Province, Philippine Islands. According to the Rev. Miguel Selga, S. J.,[2] these objects were first discovered by Prof. H. Otley Beyer near the town of Novaliches in 1926. They have been recorded from Rizal, Nueva Ecija, and Batangas Provinces, so that the stones described here are from a new locality.[3]

The form of the stones varies considerably, and among the specimens examined there appear to be three distinct types; namely, spheroid, cylindrical, and irregular.

The spheroid type.—The larger stones appear to be wholly of this type, and the largest diameter measured is 4.9 centimeters. They are characterized by a more or less pitted surface, doubtless caused by escaping gases and vapors during cooling. Often the surface is segmented by a number of curved crevasses, which do not represent shrinkage cracks such as are found in

[1] Submitted by F. W. McCaw, superintendent of artesian wells, Philippine Bureau of Public Works.

[2] Meteorites in the Philippines, Pub. Manila Observatory No. 9 (1930) 24–26.

[3] One specimen, Bureau of Science Museum No. 3886, was collected in Busuanga Island, by Mariano P. Maat. Rev. M. Selga, director of the Weather Bureau, submitted another specimen of the "spheroid type" and reported that it was collected from the Barrio of Lawaan, Wright, Samar.—V. ELICAÑO.

269099——7

quenched glass. The crevasses are not V-shaped but U-shaped, the deeper ones more nearly approaching the typical V-shape, but, nevertheless, having a slightly flattened or rounded base. They are obviously not formed after consolidation of the glass, and it is difficult to see how they could be formed by surface fusion such as stony meteorites often exhibit. If this is so, they must have formed before consolidation. It is well known that lava pools in volcanic craters are often coated with a somewhat plastic skin. It seems reasonable to assume that while still in a state of fusion these stones would become covered with a plastic skin or coating in the earlier stages of cooling. The pitted nature of the outside surface shows that a considerable amount of volatile matter is lost before consolidation. This, together with cooling, connotes a fairly large amount of shrinkage before the glass actually sets. Differences in density and perhaps elasticity of the surface coating would lead to the formation of crevasses where the coating offered least resistance to shrinkage. The surface of the crevasses always has a much better luster than the rest of the outer surface of the stones, but this may be due to greater protection from abrasion subsequent to falling. It is to be remembered that they have been found in alluvium, and are considered at least prehistoric. Sometimes the crevasses are more or less circular, forming an "island" which has a most striking resemblance to some forms of australites. The convex upper surface, the thin flange, and the facetted sides are preserved more or less perfectly in these "islands." Should the crevassing proceed to the ultimate breaking up of the stone it would result in the production of a number of australites. Mr. G. C. Clutton, of the preparatorial staff of the Australian Museum, made a cast of one of these islands; trimming the base to the bottom of the crevasse, and painting the cast black, he produced a perfect australite.

The discovery of these stones, while not disproving the "Bubble Theory" as propounded by E. J. Dunn,[4] makes it quite clear that any form of the australites, even the dumb-bell type, can be produced without the aid of a bubble.

Unfortunately, only one billitonite is available to me, but an examination of that one reveals a remarkable similarity to the spheroid type, particularly in regard to the surface crevasses.

The cylindrical type.—This is represented by one specimen

[4] Geol. Survey Victoria Bull. 27 (1912).

only, which has some slight resemblance to the poorer specimens of the dumb-bell variety of australite.

The irregular type.—This type of stone appears to be always small, and owes its irregularity to a particularly vesicular surface. These stones in no way resemble the moldavites in their irregularity of form, neither are they comparable to any australites known to me.

The color of the Philippine stones is jet black by reflected light, and olive brown by transmitted light through thin chips. In regard to color they are, therefore, comparable to both the billitonites and australites, but differ from the moldavites.

Thin sections under the microscope are seen to be completely isotropic without any indication of crystallization or structure. There appears to be a complete absence of gas bubbles in the interior.

The specific gravity of five stones was measured, giving a variation of from 2.441 to 2.448, with an average of 2.444, pointing to a remarkable uniformity in their composition. According to Summers [5] the specific gravity of the australites varies from 2.376 to 2.49. F. E. Suess [6] gives a list of specific gravity values for all obsidianites, and from this list it will be seen that the billitonites vary from 2.443 to 2.503, and the moldavites from 2.318 to 2.385. Obviously it is not possible to differentiate, by means of specific gravity determinations, between australites, billitonites, and the Philippine Islands stones, though all three are distinct from the moldavites.

A chemical analysis of one of the stones was carried out by Mr. H. P. White, formerly chief analyst to the Department of Mines, New South Wales. The result of his work is given, together with an analysis of an australite and of a billitonite, for comparison.

There is a very marked similarity between the chemical composition of the Philippine stone and that of the australite from near Coolgardie, Western Australia. There is almost as close an agreement with the billitonite from Dedang, the only difference being a somewhat higher sodic content in the billitonite. All three stones belong to the subrang Almerose of the C. I. P. W. classification.[7] Incidentally, it has been pointed out by

[5] Obsidianites—their origin from a chemical standpoint, Proc. Roy. Soc. Victoria 21 (1909) 423–443.

[6] Die Herkunft der Moldavite und verwandter Gläser, Jahrb. d. k. k. geol. Reichsanst, Vienna 50 (1900) 242–244.

[7] U. S. Geol. Surv. Prof. Paper 14 (1903).

Analyses of obsidianite, australite, and billitonite.

	I. Obsidianite, Bulacan Province, Philippine Islands, H. P. White, analyst.	II. Australite, near Coolgardie, Western Australia.[a]	III. Billitonite, Tebrung, Dendang; C. V. John, analyst.
SiO_2	70.88	70.62	70.92
Al_2O_3	12.33	13.48	12.20
Fe_2O_3	1.20	0.85	1.07
FeO	4.32	4.44	5.42
MgO	2.62	2.42	2.61
CaO	3.97	3.09	3.78
MnO	Trace.	0.42	0.14
Na_2O	1.61	1.27	2.46
K_2O	2.39	2.22	2.49
TiO_2	0.86	0.90	----------
Loss on ignition	0.18	0.07	----------
	100.36	99.75	101.75

[a] Traces of nickel and cobalt.

Norm for analysis I.

Quartz		37.68
Orthoclase	13.90	
Albite	13.62	
Anorthite	19.46	
Feldspar		46.98
$MgSiO_3$	6.50	
$FeSiO_3$	5.54	
Enstatite		12.04
Ilmenite		1.52
Magnetite		1.86
		100.08

Classification: II, 3, 3, 3, ALMEROSE.

Summers[8] that Washington has included only one analysis of a terrestrial rock under this subrang.

From the above facts it will be seen that there is a very close relationship between the billitonites and the obsidianites from the Philippine Islands. It would be a difficult matter, if not impossible, to separate the two in a mixed collection. Chemically the latter appear to be more closely related to the australites in one respect only, that is in the soda content. In view of the fact that there are only three available analyses of billitonites made before the beginning of this century and only one of the

[8] Loc. cit. p. 430.

Philippine Islands stone, it cannot be stated definitely that this constitutes a fundamental difference.

In 1909 J. B. Scrivenor [9] gave the following localities in which billitonites had been discovered: Billiton; Mount Moeriah, Djapara, Java; Pleiari, Tanah Laut, Southeast Borneo; Sungri Riam, Tanah Laut, Southeast Borneo; Bungaran (Natuna Archipelago); Blat and Gambang Valleys, Pahang; Gemas and Sungri Triang, Negri Sembilan; Sudu Seremban, Negri Sembilan.

In view of this distribution of the billitonites, it is not unreasonable to extend the area to the Philippine Islands. Further support for such an extension is to be found in their mode of occurrence. At Pahang the billitonites are found in the tin-bearing alluvium, and in the Philippine Islands I am informed that they also occur in detrital deposits.

Considering all the available evidence I have no hesitation in including the Philippine Islands obsidianites with the billitonites. I can see no justification for the new name, rizalite, as proposed by Professor Beyer and recorded by Rev. Miguel Selga.[10] It is not proposed to discuss the origin of obsidianites here, but if the meteoric origin be accepted, as it is by Rev. Miguel Selga and myself, then it would seem that a new name is not only unnecessary but undesirable.

Since making the above notes, Mr. McCaw has sent me a photograph of a type of billitonite from the Philippine Islands which differs from those already described. I suggest that this type should be called the "drop" type.

[9] Obsidianites in the Malay Peninsula, Geol. Magazine (London) 6 (1909) 411–413.

[10] Loc. cit. p. 25.

ILLUSTRATIONS

[Billitonites of various types, all from Sitio Pugad Baboy, Polo, Bulacan Province, Philippine Islands. Photographs by the Bureau of Science. Collection of F. W. McCaw.]

PLATE 1. BILLITONITES

FIG. 1. The spheroid type.
2. The cylindrical type.
3. The irregular type.

PLATE 2. BILLITONITES

FIG. 1. The drop type.
FIGS. 2, 3, and 4. Other forms of the irregular type. (These were not seen by the author.—V. ELICAÑO.)

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PLATE 1.

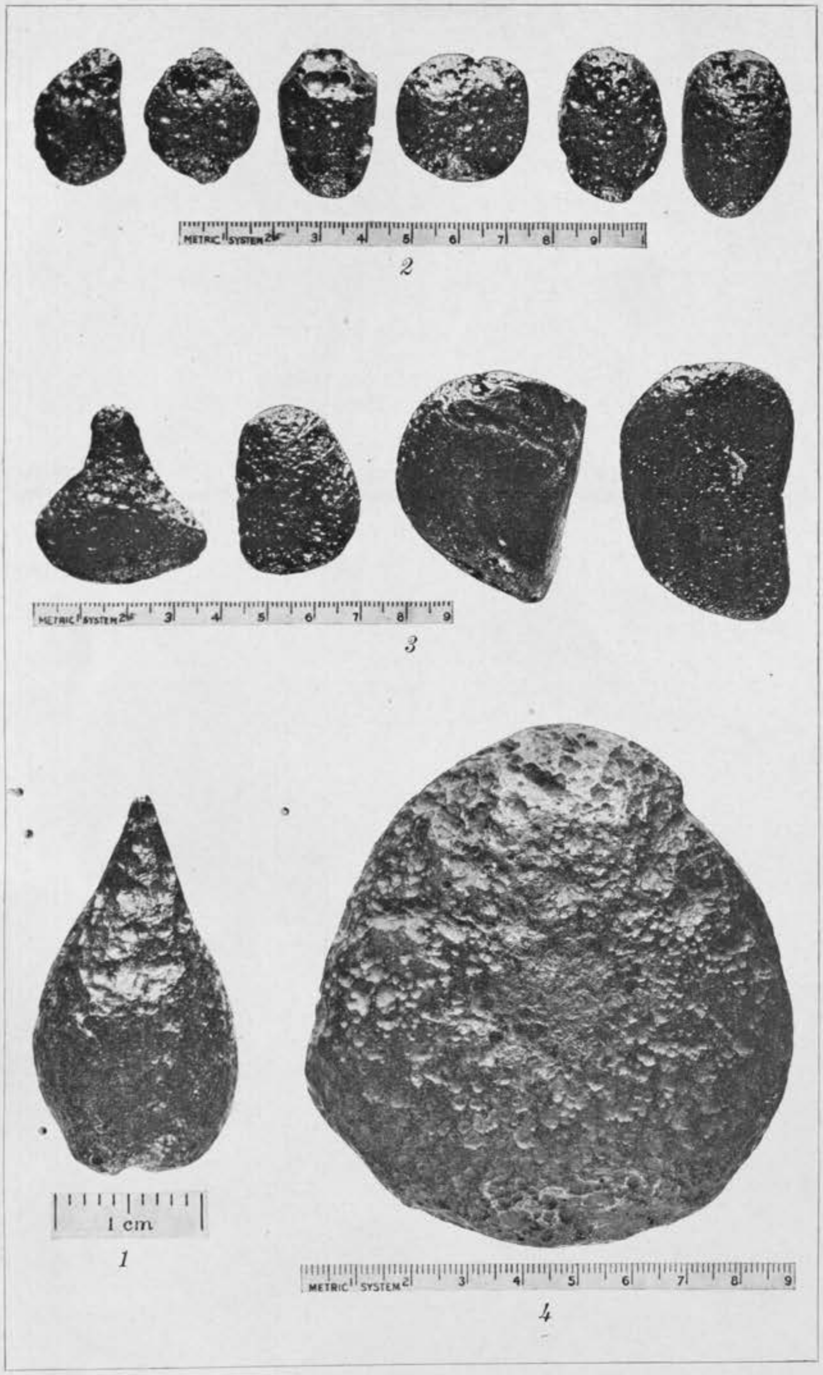

PLATE 2.

EXPERIMENTS ON THE TRANSMISSION OF SURRA BY MEANS OF THE DOG HOOKWORM ANCYLOSTOMA CANINUM [1]

By Lope M. Yutuc

Of the College of Veterinary Science, University of the Philippines Los Baños, Laguna

The puzzling results obtained by myself and others during the study of equine surra and its chemotherapy have directed my attention to the probable rôle played by blood-sucking worms present in the digestive tract of animals affected with surra. Tubangui (1930), working on the same premises, conceived the idea that blood-sucking worms may be responsible for some of the relapses occurring in the course of the treatment of the disease. The hypothesis was advanced, supported by one positive experiment, that such parasites found in surra-infected animals probably ingest the trypanosome of the disease together with the blood and that they may also be capable of reinoculating it, in a virile state, to the host during subsequent feedings. If the theory is correct, how can the promising results obtained by Broudin (1927), Reynolds (1930), and others in experimental surra be explained? Is it possible that all the treated animals were free of every kind of gastrointestinal parasite at the time of the treatment? Unfortunately, whether or not the animals employed were examined for blood-sucking worms is not stated. Parasitism in the Tropics is so common as to suggest that the animals may have harbored some kind of blood-sucking helminths. If this statement is true, a question may arise. Is it possible for the trypanocidal drug to be ingested with the blood by the blood-sucking nematodes, thus making the blood inimical to the life of the trypanosome?

[1] The writer acknowledges with thanks his indebtedness to Dean Gregorio San Agustin, of the College of Veterinary Science, University of the Philippines, Los Baños, Laguna, for his interest and assistance, supplying him with material for this work.

The main object of the present paper is to elucidate the points mentioned above. Although the data here recorded are scarcely sufficient for final conclusions, it seems worth while to report the results.

MATERIALS AND METHODS

Sixteen dogs and twelve white rats were employed in this work. These species were selected mainly because of the ease with which the animals can be handled and their marked susceptibility to the disease. The organism (*Trypanosoma evansi*) employed was obtained from a horse suffering from surra brought for treatment to the clinic of the College of Veterinary Science, Los Baños, Laguna.

The procedure adopted in the determination of the presence of the trypanosome in the body of the hookworm (*Ancylostoma caninum*) consisted in crushing the engorged worms collected from a killed surra animal, mounting them in cover-slip preparations, and examining them immediately under the microscope. In conjunction with this method, some of the engorged hookworms were selected and triturated in a sterile mortar until reduced to fine, inoculable fragments. A small amount of sterile physiological salt solution was added to the material to increase the volume to a desired amount and then injected subcutaneously into the experimental animals.

The technic followed by Tubangui was also used either alone or in combination with the above method with a slight modification; namely, instead of using a canula in the insertion of the hookworms into the small intestine, the parasites were directly introduced through an enterotomy wound about 2 centimeters long and subsequently approximated with two or three stitches of Lambert suture. With this alteration the time consumed during the operation was reduced to an average of twenty minutes, and it seemed to be less injurious to the parasites. For details of the method the original paper should be consulted.

It should be noted that in the process of collecting the hookworms from the small intestines of the killed surra dogs, the worms close to and those in contact with the incisions when the intestines were laid open were discarded to avoid, as much as possible, contamination with the trypanosomes from the blood which oozed from the incision surfaces.

EXPERIMENTAL RECORDS

DETERMINATION OF THE PRESENCE OF TRYPANOSOMES IN THE BODY OF THE DOG HOOKWORM

Experiment 1.—June 20, 1930, dog 1, previously infected with surra, was killed fifteen days after infection, when the trypanosomes were numerous in the peripheral circulation. Thirty living hookworms were collected from its small intestine and washed five times with physiological salt solution to rid them of the mucoid material and other débris adhering to their bodies. Ten of the engorged worms were crushed and mounted on slides. Microscopic examination of the ten preparations revealed one trypanosome. The organism was motile and was believed to be *Trypanosoma evansi.* Some of the red blood cells as well as the white were noted intact in the preparations examined. The rest of the worms were triturated and injected into white rats 1 and 2. After seven days, rat 1 was found positive on microscopic examination of the blood obtained from the tail. Rat 2 remained negative and its susceptibility was later tested by injecting it subcutaneously with blood rich in trypanosomes.

DETERMINATION OF THE POSSIBLE ROLE OF THE DOG HOOKWORM IN THE ARTIFICIAL TRANSMISSION OF THE SURRA ORGANISM

Experiment 2.—May 17, 1930, ten living hookworms, some of them engorged with blood and collected from killed surra dog 2, were introduced into the small intestine of dog 3, through a surgical incision, which was afterwards sutured. Microscopic examination of the blood was made every day, and the animal remained negative to June 7, 1930, twenty-two days. The animal was tested for susceptibility and caught the disease eight days later. Dog 4 received simultaneously the same treatment as above. The result was the same as the former.

Experiment 3.—August 10, 1930, dog 3, previously inoculated with surra trypanosomes and the blood teeming with organisms, was killed, and twenty-five living hookworms were collected and washed several times with physiological salt solution. Each of two dogs (Nos. 5 and 6) received ten hookworms, which were introduced into the small intestine through a surgical wound; the wound was afterwards sutured. The rest of the worms collected were triturated with a small amount of sterile physio-

logical salt solution and injected into white rat 3. Observations were made in the same manner as in experiment 2. August 20, 1930, dog 5 was positive, and dog 6 and rat 3 remained normal, their susceptibility to the disease being later proven by inoculation with blood rich in trypanosomes.

Experiment 4.—Dog 5, having been found positive in experiment 3, was used as the source of the hookworms. August 26, 1930, the trypanosomes were numerous in the peripheral circulation, hence the animal was killed. Twenty-five hookworms were collected and washed four times with physiological salt solution to remove the mucoid material which adhered in the process of collection. Five of the engorged worms were triturated with a small amount of physiological salt solution, and injected into white rat 4, while the rest were transplanted into the intestines of dogs 7 and 8 through an incision of about 2 centimeters, the edges of which were afterwards approximated. Each animal received ten living hookworms. September 4, 1930, rat 4 was found positive by microscopic examination of the blood and died three days later. Dogs 7 and 8 did not get the infection and their susceptibility was later proven by inoculation with trypanosomes.

TO DETERMINE WHETHER OR NOT THE TRYPANOSOMES INGESTED BY HOOKWORMS OF SURRA-INFECTED ANIMALS ARE AFFECTED BY THE INJECTION OF A TRYPANOCIDAL AGENT

Experiment 5.—October 11, 1930, the source of hookworms was dog 8, which was previously infected, and when the trypanosomes were numerous in the peripheral circulation it was treated with sodium antimony tartrate, 0.004 gram for each kilogram of body live weight, given intravenously. A day after the treatment, the animal was killed, and twenty-six worms were collected and treated as in previous experiments. Three animals, dogs 9 and 10 and rat 5, were employed. Each dog was infected with ten living hookworms through an operative wound in the small intestine, and the rat was injected hypodermically with six triturated worms in a small amount of physiological salt solution. The blood of the animals was examined microscopically each day. All of them remained normal for twenty-five days after infection. Their susceptibility was later proven by inoculation with trypanosomes.

Experiment 6.—December 10, 1930, dog 9, having been previously infected with the trypanosomes of surra and treated

after two relapses of the disease, was given the same dose of antimony preparation as above. The next day the animal was killed, and the hookworms were collected and washed five times with physiological salt solution. Dogs 11 and 12 received ten living hookworms each by enterotomy, and white rat 6 received seven ground worms by subcutaneous injection. The results were negative. Their susceptibility was later proven by inoculation with trypanosomes.

Experiment 7.—January 23, 1931, dog 10, which had been infected with surra trypanosomes and at which time the peripheral circulation was teeming with the organisms, was treated with an intravenous injection of sodium antimony tartrate, 0.004 gram for each kilogram live weight. Four days later the animal was killed and thirty-two hookworms were collected and treated as in previous experiments. White rats 7 and 8 received subcutaneous injections of twelve ground engorged worms in sterile physiological salt solution. The rest of the hookworms were transplanted to dogs 13 and 14 by enterotomy, each animal receiving ten living hookworms. The following day dog 13 died, cause unknown. The rest remained negative for twenty days after operation. The susceptibility of the animals was later proven by injection with blood rich in trypanosomes.

Experiment 8.—November 1, 1931, dog 15 was infected with surra. After fifteen days the blood of the animal was swarming with surra organisms, and, the animal was subsequently subjected to sodium antimony tartrate treatment. The following day the dog was killed, and thirty living hookworms were collected and washed several times with physiological salt solution. Then they were ground in a sterile mortar until reduced to fine fragments. The volume of the material was increased to about 10 cubic centimeters with physiological saline. This was injected hypodermically into white rats 9 and 10, each receiving approximately 5 cubic centimeters of the preparation. Daily observations were made. Both rats remained negative. November 20, 1931, their susceptibility was proven by inoculation with trypanosomes.

Experiment 9.—November 24, 1931, dog 16, having been infected with surra organisms and treated with antimony preparation at the time the peripheral circulation was teeming with trypanosomes, was killed two days after the treatment. Thirty-six living hookworms were collected from the intestine and washed four times with physiological salt solution. The hook-

worms were triturated in a sterile mortar until converted into fine fragments. About 10 cubic centimeters of physiological salt solution was added to the material and then immediately injected subcutaneously into white rats 11 and 12. Daily microscopical observations of the tail blood were made. The rats remained negative to December 11, 1931, or fifteen days. Their susceptibility was later proven by inoculation with blood rich in trypanosomes.

DISCUSSION

Some of the experiments show that the trypanosomes of surra are actually found in the bodies of hookworms collected from surra-infected dogs, although not as numerous as I thought at one time. This may account in part for my failure to transmit the disease with regularity as may be noted in the above experiments. The positive results observed in experiments 1, 3, and 4 tend to strengthen the hypothesis propounded by Tubangui.

The negative results of experiments 5, 6, 7, 8, and 9 may suggest one of two things or both. First the trypanosomes ingested by the hookworms may be destroyed, probably due to the entrance of the trypanocidal drug into the body of the hookworms. Second, it is possible for some of the ingested trypanosomes of the hookworms, at the time the blood of the surra animal is made inimical to their existence by the administration of sodium antimony tartrate, to escape with the ejecta of the worms before being destroyed by the trypanocidal agent. This case deserves further inquiry, notwithstanding the fact that it finds support in the observation of Wells (1931) that a single hookworm possibly withdraws and ejects 0.8 cubic centimeter of blood from the host in twenty-four hours and that the ejecta consists mainly of red clood corpuscles of the host, together with some epithelial material and bacteria.

If such a state of affair exists in the horse as in the dog, this finding demonstrates the superfluity of the administration of anthelmintics with the specific object of expelling the blood-sucking worms and forestalling relapses of the disease in connection with the treatment of equine surra with trypanocidal drugs. However, it is possible that some of the blood-sucking worms may not be continually attached to the intestinal mucosa of their hosts. Besides, they need not be continually sucking. Furthermore, these blood-sucking parasites might be sensitive to the presence of the trypanocidal agents and for this reason abstain from feeding during such time as the drug is present in the

circulation in sufficient concentration to be injurious to them. All these considerations suggest the possibility of some trypanosome-harboring worms not injesting the trypanocidal drug. On the other hand, some of the trypanocidal agents, such as the antimony preparations, naganol, Fourneau 309, and others seem to be slowly eliminated from the system, rendering almost certain their being ingested by the blood-sucking parasites sooner or later during the course of the treatment of surra.

SUMMARY AND CONCLUSIONS

Experiments on the transmission of surra by means of the dog hookworm, *Ancylostoma caninum,* were performed.

It was determined by the injection and transplantation of hookworms from dogs infected with surra to normal animals that the surra trypanosome is ingested during the process of feeding and is retained in a viable state by the helminths.

On the other hand, no evidence was observed to show that the dog hookworm can act as a place of refuge for the trypanosome in the event the blood of an infected animal is made inimical to its well-being by the administration of a trypanocidal agent, such as antimony tartrate, for it appears that it is similarly destroyed in the digestive tract of the helminths by the drug.

For this reason the administration of anthelmintics for the expulsion of blood-sucking parasites with the specific object of preventing relapses during a course of treatment against surra does not appear to be of much value.

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REYNOLDS, F. H. K., S. J. SIMMONS, and JOE H. ST. JOHN. Experimental studies of the treatment of surra. Philip. Journ. Sci. 43 (1930) 627–653.

TUBANGUI, MARCOS A. Studies on the treatment of equine surra in the Philippines, I. Philip. Agr. 18 (1930) 609–620.

WELLS, HERBERT S. Observations on the blood sucking activities of the hookworm, Ancylostoma caninum. Journ. Parasit. 17 (1931) 167–182.

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NEW OR LITTLE-KNOWN TIPULIDÆ FROM THE PHILIPPINES (DIPTERA), XV[1]

By CHARLES P. ALEXANDER
Of Amherst, Massachusetts

THREE PLATES

The Tipulidæ collected in Davao district, Mindanao, in 1930 and 1931, by Mr. Charles F. Clagg, are further discussed at this time. All types are preserved in my collection.

TIPULINÆ

PSELLIOPHORA INVENUSTIPES sp. nov. Plate 1, fig. 1.

General coloration yellow, conspicuously variegated with black, including the occipital region of head and three clearly defined stripes on the mesonotal præscutum; legs black, unvariegated; wings dimidiate, the basal two-thirds yellow, the apical third, together with cells C, Sc, and Cu_1, dark brown; abdominal tergites yellow, trivittate with black.

Male.—Length, about 14 millimeters; wing, 14.5.

Frontal prolongation of head obscure yellow, dark brown laterally; nasus a little darker, tufted with yellow setæ; palpi pale yellow, the extreme tip of the terminal segment dark brown. Antennæ with the scape obscure yellow; remaining segments, including the pedicel, black. Head orange, the occipital area black and very extensive.

Pronotum yellow medially, blackened laterally. Mesonotal præscutum yellow, with three very distinct brownish black stripes, the median one not quite attaining the suture; lateral stripes crossing the suture onto the scutal lobes which are largely covered by these areas; remainder of mesonotum yellow, the scutellum with a median infuscation; postnotal mediotergite with paired brown spots on caudal half. Pleura chiefly yellow, the ventral sternopleurite and meral region infuscated. Halteres brownish black, the basal fourth of stem yellow. Legs with

[1] Contribution from the entomological laboratory, Massachusetts State College.

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the coxæ yellow, narrowly margined with brown at base; trochanters obscure brownish yellow; remainder of legs entirely black. Wings (Plate 1, fig. 1) dimidiate, cells C, Sc, and Cu_1, together with the stigma, dark brown; basal two-thirds of remainder of wing yellow, with vague dusky streaks in centers of major cells; distal third of wing, including all cells beyond cord, uniformly dark brown, paler than the costal darkening. Venation: Cell M_1 sessile.

Abdominal tergites yellow, trivittate with black; median areas of segments two to four broadly interrupted by yellow at caudal margins; on succeeding tergites the black median areas become more extensive; lateral dark stripes beginning on outer half of tergite two, on succeeding three segments narrowly interrupted by yellow on basal portion of each tergite, on outer segments more continuous; sternites yellow, clearer on caudal margin; sternites four and five with a small darkened basal triangle; hypopygium chiefly yellow, the tergal portions and styli black. Male hypopygium with the eighth sternite produced medially into a conspicuous dusky lobe that bears abundant golden setæ.

MINDANAO, Davao district, Calian, Sibulan Barrio, flying in field of abacá at foot of Mount Apo, altitude 2,000 feet, October 8, 1930 (*Clagg*); holotype, male.

Pselliophora invenustipes is quite distinct from all other regional species in the uniformly blackened legs, in conjunction with the pattern of the body and wings. By Edwards's key to the Philippine species of *Pselliophora* [2] the fly runs to couplet 3, agreeing most closely with *P. perdecora* Alexander, which has an entirely different wing pattern.

DOLICHOPEZA (NESOPEZA) PERDITA sp. nov. Plate 1, fig. 2; Plate 2, fig. 21.

Most closely allied to *abdita;* mesonotal præscutum pale brown, unmarked; posterior sclerites of mesonotum dark brown; pleura pale; femora and tibiæ dark, the posterior tarsi entirely white; wings narrow, long-petiolate basally; Rs long; male hypopygium with the caudal margin of tergite bearing two large blackened teeth; inner dististyle unusually narrow, boomerang-shaped.

Male.—Length, about 9 to 10 millimeters; wing, 11 to 11.5.

Frontal prolongation of head brownish yellow; palpi dark brown. Antennal scape and pedicel obscure yellow; flagellum black; antennæ about as long as the combined head and thorax; flagellar segments with verticils that are much shorter than

[2] Notulæ Entomologicæ 6 (1926) 41.

the segments. Head pale brown, with a large, darker brown spot on either side of posterior vertex, extending from eye to occiput.

Mesonotal præscutum pale brown, without evident markings; posterior sclerites of mesonotum dark brown, including the pleurotergite. Pleura yellow. Halteres dusky, the knobs dark brown. Legs with the coxæ yellow; trochanters testaceous yellow; femora dark brown, the bases restrictedly pale; tibiæ black, the posterior tarsi entirely snowy white; mid-tarsi with almost all of basitarsi black, the tips and remainder of tarsi white; forelegs broken. Wings (Plate 1, fig. 2) with a brown tinge, the oval stigma darker brown; obliterative areas before and beyond the stigma and across the fork of M poorly defined; veins dark brown. Wings much narrower than in *abdita*, conspicuously petiolate at base. Venation: Rs elongate, more than one-third longer than R_{2+3} ; cells beyond cord narrower than in *abdita;* cell 2d A narrow.

Abdominal tergites brownish black; basal sternites obscure yellow; hypopygium dark. Male hypopygium (Plate 2, fig. 21) with the ninth tergite, *9t*, produced on either side into a powerful blackened tooth, the median region very feebly produced; ventral extensions of tergal lobes slender, the tips bidentate, but without other serrulations. Eighth sternite, *8s*, pale, narrowed outwardly, the caudal margin medially very gently emarginate, on either side of midline with a denser grouping of weak setæ. Inner dististyle, *id*, unusually narrow, boomerang-shaped, the base weakly setiferous, the apex truncated.

MINDANAO, Davao district, Calian, Mount Apo, Todaya Plateau, altitude 5,000 feet, November 11, 1930 (*Clagg*); holotype, male; paratype, male.

Dolichopeza (*Nesopeza*) *perdita* is allied to *D.* (*N.*) *abdita* Alexander (Mindanao) in the elongate Rs, unmarked wings, and general pattern of the legs. It is very different in the narrow, long-petiolate wings and the structure of the male hypopygium, especially the toothing of the tergite and the very narrow inner dististyle. In *abdita*, the inner dististyle is unusually broad and flattened.

DOLICHOPEZA (NESOPEZA) QUERIBUNDA sp. nov. Plate 1, fig. 3; Plate 2, fig. 22.

Belongs to the *gracilis* group; most nearly allied to *nigrofemorata;* general coloration of mesonotum yellowish brown, without distinct markings; tibiæ infuscated, paling to obscure

whitish before tips; wings with a brown tinge, the costal border dark brown, not abruptly brightened in outer end of cell R_2; male hypopygium with the lateral lobes of the ninth tergite very broad, truncated; eighth sternite with a row of long setæ on either lateral lobe, these becoming progressively shorter toward the midline.

Male.—Length, about 8 to 9 millimeters; wing, 9 to 10.5.

Frontal prolongation of head dark brown; palpi black. Antennæ with the scape, pedicel, and base of first flagellar segment yellow, the remainder of organ dark brown; flagellar segments cylindrical, with scanty, very short verticils that scarcely exceed in length the abundant white pubescence. Head light brown, the anterior vertex a trifle brighter.

Mesonotal præscutum and scutum yellowish brown, the former a little darker on cephalic third but not otherwise marked; scutellum and postnotal mediotergite a trifle darker. Pleura light brown, the dorsopleural region and pteropleurite more yellowish. Halteres yellow, the knobs dark brown. Legs with the coxæ and trochanters testaceous-yellow; femora brown, more yellow at base; tibiæ infuscated, passing to obscure whitish before the very narrow dark brown tips; proximal ends of basitarsi narrowly darkened; remainder of tarsi white. Wings (Plate 1, fig. 3) with a brownish tinge, the costal border dark brown; central portion of cell R_2 paler but without abruptly delimited white central areas, as in most species of the group; posterior extensions along origin of Rs and at cord narrower than in *nigrofemorata*. Venation: Cell 2d A narrow.

Abdominal tergites brownish black, the bases of the segments narrowly brightened, the outer segments uniformly blackened; sternites yellow on basal portion, the distal half or more brownish black; hypopygium brownish black. Male hypopygium (Plate 2, fig. 22) with the ninth tergite, *9t*, transverse, the lateral lobes very broad, truncated; median lobe low and obtuse. Apical lobe of inner dististyle, *id*, elongate. Eighth sternite, *8s*, transversely rectangular, the caudal margin gently emarginate; lateral lobes with a fringe of long black setæ, the outer ones longest, gradually decreasing in length toward the median line.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet, January 27, 1931 (*Clagg*); holotype, male; paratypes, 2 males.

By my key to the Philippine species of *Dolichopeza*[3] the present species runs to *D.* (*N.*) *nigrofemorata* Alexander (Mindanao) which is very distinct in the structure of the male hypopygium. The present fly is well differentiated by the very broad, truncated lobes of the tergite and the arrangement and nature of the setæ on the eighth sternite.

DOLICHOPEZA (NESOPEZA) LUDIBUNDA sp. nov. Plate 2, fig. 23.

Belongs to the *gracilis* group; most nearly related to *nigrofemorata* and *queribunda;* general coloration of mesonotum light brown, without distinct markings; wings with a dark costal pattern; cell R_2 variegated by a single pale area; male hypopygium with the lateral lobes of the tergite small, narrower than the median notch separating them; caudal margin of eighth sternite nearly transverse, with weak setæ that are not grouped into tufts or brushes.

Male.—Length, about 8 millimeters; wing, 8.2.

Frontal prolongation of head testaceous-yellow; palpi dark brown. Antennæ (male) elongate, if bent backward extending about to root of halteres; scape, pedicel, and basal segment of flagellum yellow, the remainder of organ passing to brown; flagellar segments cylindrical, clothed with an abundant white pubescence; verticils scarcely developed. Head pale yellowish brown.

Mesonotum light brown, the præscutum with scarcely apparent stripes; posterior sclerites of mesonotum more infuscated. Pleura almost uniformly brownish yellow, the anepisternum a trifle more darkened. Halteres with the stem pale brown, the knobs brownish black. Legs with the coxæ and trochanters pale yellow; remainder of legs broken. Wings of the general type of *nigrofemorata,* including a dark costal pattern that is almost continuous, being interrupted by a single pale area in cell R_2. Venation: Forks of medial field deep.

Abdominal tergites brownish black medially, the individual segments variegated laterally with yellow on basal half; hypopygium dark. Male hypopygium (Plate 2, fig. 23) with the ninth tergite, *9t,* small, the lateral lobes glabrous, blackened, the median notch evenly rounded, wider than the diameter of either lateral lobe. Eighth sternite, *8s,* pale, the caudal margin nearly transverse and with few outstanding bristles, the most evident

[3] Philip. Journ. Sci. 47 (1932) 169–171.

grouping being a linear arrangement of from six to eight shorter, more spinous setæ on either side of median line.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet, January 28, 1931 (*Clagg*); holotype, male.

By my key to the Philippine species of *Dolichopeza*[4] the present fly runs to *nigrofemorata* Alexander, to which species and *D.* (*N.*) *queribunda* sp. nov. it is most nearly allied. The outline of the ninth tergite and the setal armature of the eighth sternite are distinctly different from the same features in these or any other described regional species.

DOLICHOPEZA (NESOPEZA) EVANIDA sp. nov. Plate 2, fig. 24.

Belongs to the *gracilis* group; general coloration of mesonotum pale, the præscutum with three dark brown stripes; pleura pale, conspicuously variegated with brown areas; male hypopygium with the median region of the eighth sternite produced caudad beyond the level of the lateral lobes, the latter with a row of stout spines.

Male.—Length, about 9 millimeters; wing, 8.5.

Frontal prolongation of head and the palpi dark brown. Antennæ with the three basal segments yellowish, the outer segments more infuscated; antennæ relatively long; flagellar segments long-cylindrical, with short verticils. Head light brown.

Mesonotal præscutum obscure whitish, with three dark brown stripes, the median one further divided by a capillary darker brown line; scutal lobes conspicuously marked with dark brown, the anterior darkened area circular in outline, sending a narrower darkening backward; posterior sclerites of mesonotum brown. Pleura pale, almost white, variegated by dark brown areas that include the ventral sternopleurite, meral region, anepisternum, cephalic edge of pteropleurite, pleurotergite, and the fore coxæ. Halteres elongate, pale, the knobs dark brown. Legs with the fore coxæ dark brown, the remaining coxæ and all trochanters yellow; femora yellow, the tips broadly dark brown; tibiæ chiefly yellow, the outer end more golden yellow, the basal portion weakly darkened; tarsi white. Wings subhyaline, with the usual dark brown costal pattern of the *gracilis* group, the dark color variegated by pale spots in outer ends of cells R_2 and R_3; veins dark. Venation: Medial forks deep.

Abdominal tergites dark brown, the basal segments variegated

[4] Loc. cit.

with obscure yellow just before the caudal margins, the outer segments more uniformly darkened; sternites clearer yellow, the caudal margin and basal ring of the individual segments more darkened. Male hypopygium (Plate 2, fig. 24) with the median region of the tergite, 9*t*, produced into a low protuberance, the lateral lobes obliquely truncated, the ventral surface produced into spinose lobes. Eighth sternite, 8*s*, with the median area produced caudad beyond the level of the lateral lobes, unarmed except for delicate setulæ; lateral lobes low, lying close to the median area, each armed with a row of powerful spines.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, December 31, 1930 (*Clagg*); holotype, male.

Dolichopeza (*Nesopeza*) *evanida* is quite distinct from the allied *D.* (*N.*) *paucispinosa* Alexander (Mindanao) in the details of structure of the male hypopygium, especially of the eighth sternite. By my key to the Philippine species of the genus [5] the fly runs directly to *paucispinosa*.

DOLICHOPEZA (NESOPEZA) PUDIBUNDA sp. nov. Plate 2, fig. 25.

Belongs to the *gracilis* group; general coloration of mesonotal præscutum obscure yellow, the usual stripes reddish brown and poorly delimited; pleura pale, conspicuously variegated with brown; wings with the usual dark costal pattern of the group, the outer ends of cells R_2 and R_3 variegated with pale spots; male hypopygium with the caudal margin of the eighth sternite gently emarginate, provided with four groups of setæ, the lateral groups slenderer and arranged in coarse pencils, the submedian groups distributed in a linear series, shorter and more spinous.

Male.—Length, about 9 millimeters; wing, 8.5.

Female.—Length, about 11 millimeters; wing, 9.

Frontal prolongation of head and palpi dark brown. Antennæ pale yellowish brown, in male relatively long, if bent backward extending about to base of abdomen; flagellar segments long-cylindrical, with short, inconspicuous verticils. Head brown.

Mesonotal præscutum obscure yellow, with scarcely differentiated reddish brown stripes; posterior sclerites of mesonotum light brown. Pleura pale, conspicuously variegated with brown on the ventral sternopleurite, meral region, anepisternum, and fore coxæ. Halteres long, pale yellow, the knobs dark brown. Legs with the fore coxæ dark, the remaining coxæ and all tro-

[5] Loc. cit.

chanters yellow; femora yellow, the tips narrowly dark brown; tibiæ whitish, the tips very narrowly and weakly darkened; tarsi white. Wings as in the *gracilis* group, the outer ends of cells R_2 and R_3 variegated with large pale spots; veins pale brown.

Abdominal tergites dark brown, before their caudal margins with a median yellow area; sternites yellow, narrowly marked with dark brown at near midlength and again at caudal margin. Male hypopygium (Plate 2, fig. 25) with the median region of the tergite, *9t*, produced, the lateral lobes relatively small and inconspicuous. Eighth sternite, *8s*, only gently emarginate across its caudal margin, provided with four groups of setæ and weak spines, as follows: Outer lateral angles with pencils of more elongate setæ; on either side of median line, the caudal margin with a linear series of shorter and stouter, more spinous setæ; disk of sternite with two linear rows of punctures, converging behind.

MINDANAO, Davao district, Calian, Mount Apo, Baroring River, altitude 6,000 feet, November 10, 1930 (*Clagg*); holotype, male; allotype, female.

By my key to the Philippine species of *Dolichopeza*[6] the present species runs to *D.* (*N.*) *paucispinosa* Alexander, to which species and to *D.* (*N.*) *evanida* sp. nov. it is most closely allied. All three species are readily told among themselves by the details of structure of the male hypopygium, especially the conformation of the eighth sternite and the arrangement of setæ and spines thereon.

LIMONIINÆ

LIMONIINI

LIMONIA (LIBNOTES) TENUICLAVA sp. nov. Plate 1, fig. 4; Plate 2, figs. 26, 27.

General coloration of mesonotum dark brown, the pleura brownish yellow with a dorsal black longitudinal stripe; antennæ (male) nodulose, the segments with long glabrous apical necks; halteres darkened; femora dark brown, the tips narrowly yellow; wings with a faint brown tinge, the costal region a little darker; m-cu just before midlength of cell 1st M_2; anal veins parallel at origin; male hypopygium with the basistyles elongate, the ventromesal lobe unusually slender; inner dististyle a low oval fleshy lobe, the outer margin extended into a

[6] Loc. cit.

hornlike portion that bears about seven flattened teeth to form a comblike structure.

Male.—Length, about 4 millimeters; wing, 4.5.

Rostrum and palpi brownish black. Antennæ (male) relatively elongate, nodulose (Plate 2, fig. 26); black throughout; individual flagellar segments enlarged, suboval, with abundant long erect delicate setæ and still longer, unilaterally arranged verticils on outer face; apical pedicels very long, on basal flagellar segments nearly equal in length to the enlargements, becoming shorter on the outer segments, on the penultimate about one-half the enlarged portion; terminal segment elongate, gradually narrowed to the apex. Head dark colored.

Mesonotum badly discolored, dark brown or brownish black medially, the præscutum extensively pale brown on sides. Pleura brownish yellow, the anepisternum and propleura blackened, producing a dark dorsolongitudinal area. Halteres brownish black, the base of stem narrowly pale. Legs with the fore coxæ blackened, the remaining coxæ and all trochanters yellow; femora dark brown, the tips narrowly and abruptly light yellow; tibiæ and tarsi pale brown to yellowish brown. Wings (Plate 1, fig. 4) with a faint brownish tinge, the costal region and a seam along vein Cu_1 somewhat darker; stigma very small, darker brown; veins and macrotrichia dark brown. Macrotrichia of veins very long; costal fringe of moderate length only. Venation: Sc of moderate length, Sc_1 ending beyond fork of Rs but before level of r-m, Sc_2 at its tip; Rs arcuated; free tip of Sc_2 lying a little proximad of R_2; m-cu just before midlength of cell 1st M_2; anal veins parallel at origin.

Abdomen chiefly dark brown, the incisures somewhat paler; hypopygium dark. Male hypopygium (Plate 2, fig. 27) with the tergite, *9t*, gently emarginate, each lobe slightly rounded and provided with four or five setæ. Basistyle, *b*, long and narrow, its ventromesal lobe subbasal in position, unusually slender. Dorsal dististyle, *dd*, a slightly curved, sclerotized rod, the tip acute. Ventral dististyle, *vd*, of peculiar structure, appearing as a flattened, oval, fleshy lobe, the mesal portion produced into a rostrum; on outer margin of style a hornlike extension that bears a series of about seven flattened comblike darkened teeth, the outer ones broader. Gonapophyses, *g*, with the mesal lobe elongate, flattened, the tip obtuse.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet, January 28, 1931 (*Clagg*); holotype, male.

By Edwards's key to the species of *Libnotes*[7] the present species runs to couplet 61, disagreeing with all species beyond this point in coloration, and especially in the peculiar structure of the male hypopygium. The fly is amply distinct from other species of *Libnotes* known from the Philippines. The elongate, nodulose antennæ remind one of the condition found in the closely allied subgenus *Limonia* (as *multinodulosa* Alexander) but the present fly certainly belongs to *Libnotes*.

LIMONIA (LIMONIA) PATULA sp. nov. Plate 1, fig. 5; Plate 2, fig. 28.

General coloration of mesonotum light yellowish brown, the dorsal thoracic pleurites darkened; eyes contiguous above; halteres darkened; legs pale brown, the tips of the femora and tibiæ very narrowly darkened; wings subhyaline, the brown stigma nearly circular in outline; male hypopygium very complex in structure, especially the basistyle which is extended ventrally and bears numerous apical lobes.

Male.—Length, about 5 millimeters; wing, 5.5.

Female.—Length, about 5.5 millimeters; wing, 5.5.

Rostrum and palpi black. Antennæ brownish black; flagellar segments oval to short-cylindrical; terminal segment elongate, one-half longer than the penultimate, narrowed outwardly; verticils relatively short and inconspicuous. Eyes contiguous on vertex, separating the anterior vertex from the posterior sclerites of head; ommatidia relatively coarse. Head gray.

Mesonotum light yellowish brown. Pleura yellow, the dorsal sclerites more infuscated. Halteres dark brown, the base of stem narrowly yellow. Legs with the fore coxæ darkened, remaining coxæ and all trochanters yellow; remainder of legs very pale brown, the tips of the femora and tibiæ very narrowly and weakly darkened. Wings (Plate 1, fig. 5) subhyaline, the pale brown stigma nearly circular in outline; veins brown. Venation: Sc_1 ending about opposite two-thirds Rs, Sc_2 close to its tip; Rs long, gently arcuated, approximately four times the basal section of R_{4+5}; free tip of Sc_2 and R_2 nearly in transverse alignment; m-cu at fork of M; vein 2d A converging gently toward 1st A at base, thence gently sinuous to margin.

Abdominal tergites dark brown, the sternites yellow; in male, the caudal margins of the individual tergites narrowly pale; hypopygium dark. Male hypopygium (Plate 2, fig. 28) very complex in structure. Ninth tergite, 9*t*, with the caudal margin

[7] Journ. Fed. Malay States Mus. (1928) 74–80.

convexly rounded, the median portion slightly emarginate; setæ of tergite relatively few in number. Basistyle, *b*, extensive, very complicated by lobes as shown (drawn from a dissected mount, to show relative position); in addition to the lobes, the basistyle bears a flattened sclerotized plate with about three or four long setæ near its base. Dorsal dististyle, *dd*, a straight rod, narrowed to the subacute tip, the surface of style with microscopic setulæ. Ventral dististyle, *vd*, an oval fleshy lobe, with an elongate rostral prolongation that is bent at near midlength at a right angle. Gonapophyses, *g*, elongate, subtending the ædeagus, sinuous and angularly bent at near midlength, the tips obtusely rounded.

MINDANAO, Davao district, Calian, Mount Apo, Baroring River, altitude 6,000 feet, November 10, 1930 (*Clagg*); holotype, male; allotype, female.

In the remarkable development of lobes on the basistyle and the peculiar structure of the dististyles of the male hypopygium, the present species is approached by three allied regional species, *Limonia* (*Limonia*) *bilobulifera* Alexander (Luzon), *L.* (*L.*) *davaoensis* Alexander (Mindanao), and *L.* (*L.*) *pendleburyi* (Edwards) (Federated Malay States), differing from all in the much greater complexity of the male hypopygium, notably of the basistyles and dististyles.

LIMONIA (LIMONIA) DESIDERATA sp. nov. Plate 1, fig. 6.

General coloration light ocherous yellow; thoracic pleura with a brown longitudinal stripe; halteres dusky, the base of stem yellow; legs yellow; wings pale yellow, the stigma brown; Sc_1 ending about opposite one-third the length of Rs; cell 1st M_2 open by the atrophy of the basal section of M_3, cell 2d M_2 small; abdominal tergites bicolorous, dark brown, conspicuously ringed on caudal margins with light yellow.

Female.—Length, about 5 millimeters; wing, 4.

Rostrum and palpi brown. Antennæ dark throughout; flagellar segments oval, with verticils that slightly exceed the segments; terminal segments elongate. Head dark colored.

Mesonotum light ocherous yellow, the præscutum without distinct stripes; scutal lobes slightly darkened; scutellum testaceous yellow; postnotal mediotergite weakly darkened. Pleura obscure yellow, with a distinct brown longitudinal stripe extending from the propleura, passing beneath the root of the halteres to the abdomen; ventral sternopleurite darkened. Halteres dusky, the base of stem narrowly yellow. Legs with the coxæ

and trochanters yellowish testaceous; remainder of legs yellow, the terminal tarsal segments darkened. Wings (Plate 1, fig. 6) with a pale yellow tinge, the short-oval stigma brown; scarcely evident darker clouds at origin of Rs and along cord; veins brownish yellow. Macrotrichia of veins relatively numerous, quite lacking on Sc. Venation: Sc_1 ending about opposite one-third the length of Rs, Sc_2 some distance from its tip, lying just distad of origin of Rs; free tip of Sc_2 and R_2 in transverse alignment; cell 1st M_2 open by the atrophy of the basal section of M_3; cell 2d M_2 small, about three-fifths as long as its petiole; m-cu at fork of M, longer than the distal section of Cu_1; anal veins gently converging at bases, thence gradually diverging.

Abdominal tergites dark brown, conspicuously ringed on their caudal margins with light yellow, the color becoming narrower and more obscure on segments six and seven; genital segments yellow; sternites obscure yellow, the basal two-thirds of the individual segments more yellowish brown. Ovipositor with the tergal valves slender, gently upcurved.

MINDANAO, Davao district, Calian, Mount Apo, Galog River, altitude 6,000 feet, September 8, 1930 (*Clagg*); holotype, female.

Limonia (*Limonia*) *desiderata* is quite distinct from all other regional species of *Limonia*. The only other species of the subgenus having cell 1st M_2 open by the atrophy of the basal section of M_3 is *L.* (*L.*) *bagobo* Alexander, an otherwise very different fly. The possibility exists that the unique type may have an abnormal venation, but this is similar on the two wings and certainly appears to represent a normal condition. If the basal section of M_3 was abnormally lost in this type, cell 1st M_2 would necessarily be of a most unusual length in the present group of crane flies. The general appearance of the fly is quite distinct from that of any species of *Limonia* or *Dicranomyia* in Mindanao.

LIMONIA (DICRANOMYIA) PUNCTULATOIDES sp. nov. Plate 1, fig. 7; Plate 2, fig. 29.

Belongs to the *punctulata* group; male hypopygium with the rostral prolongation of the ventral dististyle with two long slender spines, arising close together from scarcely developed basal tubercles; gonapophyses with the mesal apical angles long and slender, the margins smooth.

Male.—Length, about 5 to 5.5 millimeters; wing, 6 to 6.5.

Female.—Length, about 5.5 to 6 millimeters; wing, 6 to 6.5.

Rostrum and palpi black. Antennæ with the scapal segments black, the flagellum somewhat paler; flagellar segments short-

oval, the outer segments a trifle more elongate; terminal segment large. Head brownish gray.

Mesonotum brownish gray, the præscutum with two intermediate darker brown stripes, the usual lateral stripes poorly indicated; scutal lobes brown; scutellum and postnotal mediotergite light gray. Pleura dark brownish gray. Halteres pale, the base of knobs weakly darkened. Legs with the coxæ dark brown; trochanters yellowish brown to brown; femora yellowish brown, a little darker outwardly; tibiæ and tarsi brownish yellow. Wings (Plate 1, fig. 7) as in *punctulata* and allies, whitish subhyaline, with a spotted and dotted brown and gray pattern; a series of six to eight dots in cell C; an oval spot at about one-third the length of vein M; the usual two spots on vein 2d A; a variable number of small washes in cell M adjoining vein Cu_1; other darkened dots along cord, outer end of cell 1st M_2, along margin of wing at ends of longitudinal veins, and as variable clouds along R_{4+5}; veins pale, darker in the clouded areas. Venation: Sc_1 ending opposite origin of Rs, Sc_2 near its tip; Rs straight; cell 1st M_2 long, about equal to vein M_{1+2} beyond it.

Abdomen dark brown. Male hypopygium (Plate 2, fig. 29) with the ninth tergite, *9t,* notched medially. Ventral dististyle, *vd,* large and fleshy, the rostral prolongation with two relatively long slender spines that arise close together at beyond midlength of the prolongation from very small basal tubercles. Gonapophyses, *g,* with the mesal apical angle elongate, slender, the margins smooth.

MINDANAO, Davao district, Calian, Mount Apo (*Clagg*); holotype, male, altitude 6,000 feet, October 18, 1930; allotype, female, with the type; paratypes, 6 males and females, altitude 6,000 to 6,500 feet, September 14 to November 10, 1930.

Limonia (*Dicranomyia*) *punctulatoides* is most nearly allied to *L.* (*D.*) *subpunctulata* Alexander (Formosa) in the bispinous rostral prolongation of the male hypopygium and the untoothed lobes of the gonapophyses. It differs conspicuously in the long rostral spines and the very long, slender, mesal-apical lobes of the gonapophyses.

LIMONIA (DICRANOMYIA) MORONIS sp. nov. Plate 2, fig. 30.

Belongs to the *morio* group; most nearly allied to *benguetensis;* male hypopygium with the rostral prolongation of the ventral dististyle bearing a conspicuous pale spine; apex of dorsal dis-

tistyle obliquely truncated, entirely straight and unnotched; gonapophyses with the mesal-apical lobe very broad.

Male.—Length, about 5.5 to 6.5 millimeters; wing, 6 to 7.5.

Female.—Length, about 5.5 to 6 millimeters; wing, 5.5 to 6.

Rostrum black dorsally, brownish yellow laterally; palpi black. Antennæ black throughout; flagellar segments oval, becoming more elongate outwardly, the verticils slightly exceeding the segments; terminal segment long, about one-third longer than the penultimate, constricted at near midlength. Front and the broad anterior vertex silvery white; posterior portions of head black, sparsely pruinose.

Mesonotum polished black, the humeral region of præscutum a little brightened; posterior margin of scutellum obscure yellow. Pleura black, with a heavy silvery pruinosity on propleura, dorsal anepisternum, ventral sternopleurite, and meral region. Halteres brownish black, the basal half or more of stem yellow. Legs with the fore coxæ blackened, the remaining coxæ and all trochanters yellow; remainder of legs black, the femoral bases restrictedly obscure yellow. Wings with a strong brown tinge, the oval stigma darker brown; veins brown. Venation: Sc_1 ending opposite or just before the origin of Rs, the latter long, in alignment with R_{2+3}; m-cu at or before fork of M.

Abdominal segments conspicuously ringed with black and obscure yellow, the bases of the segments black, the caudal margins yellow, the amount of the latter decreasing on the outer segments; terminal segments, including the hypopygium, entirely black. Male hypopygium (Plate 2, fig. 30) with the structure of the tergite, *9t*, and basistyle, *b*, almost as in *benguetensis*. Ventral dististyle, *vd*, with a single conspicuous pale spine on rostral prolongation. Dorsal dististyle, *dd*, with the apex obliquely truncated, not notched. Gonapophyses, *g*, with the mesal-apical lobes very broad.

MINDANAO, Davao district, Calian, Mount Apo, Lake Lino and Kidapawan trail, altitude 7,000 to 8,000 feet (*Clagg*); holotype, male; allotype, female, September 19, 1930; paratypes, 5 of both sexes, September 19 and 20, 1930.

Limonia (*Dicranomyia*) *moronis* is close to *L.* (*D.*) *benguetensis* Alexander (Luzon), differing most conspicuously in the structure of the dorsal dististyle and gonapophyses of the male hypopygium.

LIMONIA (GERANOMYIA) IMMOBILIS sp. nov. Plate 1, fig. 8; Plate 2, fig. 31.

Mesonotal præscutum buffy yellow, with three narrow blackish stripes; rostrum and antennæ entirely black; head blackish, with a narrow median gray line extending from front to occiput; femora black, except at bases; wings with a heavy brown pattern, the areas at origin of Rs and tip of Sc separated; Sc long; m-cu some distance before fork of M; male hypopygium with the two rostral spines arising from a common base; gonapophyses with the mesal-apical lobe irregularly toothed along inner margin.

Male.—Length, excluding rostrum, about 5 millimeters; wing, 5.6 to 5.8; rostrum, about 1.7 to 1.8.

Female.—Length, excluding rostrum, about 5.5 millimeters; wing, 6; rostrum, about 2.

Rostrum black throughout, relatively short and powerful; palpi black. Antennæ black throughout; flagellar segments short-oval to subcylindrical, the verticils short and inconspicuous. Posterior vertex blackish, the front, anterior vertex, and a posterior extension of the latter to the occiput light gray; anterior vertex narrower than the diameter of the scape.

Pronotum ocherous yellow, with a narrow black median line; lateral margins narrowly darkened. Mesonotal præscutum buffy yellow, the lateral margins paling to light gray; three narrow blackish stripes, the median one a direct posterior extension of the pronotal median darkening, the stripe paling to gray before the suture; lateral stripes narrow but long, separated from the median line by interspaces of about equal width; scutal lobes brownish gray, each marked near mesal edge by a brown line; scutellum buffy, with a median black line that is continued cephalad onto the median region of the scutum; postnotal mediotergite brownish gray. Pleura with the sternopleurite light yellow, the remainder of pleura chiefly dark brown, sparsely pruinose. Halteres yellow, the knobs dark brown. Legs with the coxæ and trochanters yellow; femora black, the bases narrowly yellow; tibiæ brown, the tips weakly darkened; tarsi yellow, the tips of the basal segments narrowly darkened, the terminal segments brownish black. Wings (Plate 1, fig. 8) whitish subhyaline, the prearcular region light yellow; a heavy brown pattern, arranged as a series of about seven costal areas, the third at origin of Rs, fourth at tip of Sc_1, fifth, largest, at

stigma; additional dark areas at fork of Rs, on anterior cord, m-cu, outer end of cell 1st M_2 and a marginal series at outer ends of cells 2d M_2 and M_4, and at ends of both anal veins; veins brown, costal and subcostal veins yellow, dark brown in the darkened areas. Costal fringe short. Venation: Sc long, Sc_1 ending opposite three-fifths to three-fourths the length of Rs, Sc_2 near its tip; cell 1st M_2 long, subequal to vein M_{1+2} beyond it; m-cu from two-thirds to three-fourths its own length before the fork of M; anal veins at origin nearly parallel.

Abdominal tergites dark brown, the sternites obscure yellow, darker on outer segments. Male hypopygium (Plate 2, fig. 31) with the caudal margin of the ninth tergite, *9t*, gently emarginate. Ventral dististyle, *vd*, large and fleshy, much larger than the basistyle, *b;* rostral prolongation with two relatively long, gently curved spines from a common basal tubercle. Gonapophyses, *g*, with the mesal-apical lobe elongate, its inner margin conspicuously and irregularly toothed.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, December 31, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 2 males.

Among the described regional species of the subgenus, *Limonia* (*Geranomyia*) *immobilis* seems to be most closely allied to *L.* (*G.*) *suensoniana* Alexander (eastern China), agreeing in the chief features of wing venation, as the long Sc and position of m-cu, differing in the distribution of the brown areas of the wing, especially along the posterior margin, and very conspicuously in the details of structure of the male hypopygium.

HEXATOMINI

ATARBA (ATARBODES) APOENSIS sp. nov. Plate 1, fig. 9; Plate 3, fig. 32.

General coloration of mesonotum yellowish brown; pleura yellow, the pteropleurite conspicuously blackened; antennal flagellum pale brown; legs yellow; wings yellow, the anterior branch of Rs subequal in length to Rs, diverging strongly from the posterior branch; male hypopygium with the lateral spines of the outer dististyle erect and strongly curved; ædeagus deeply trifid at apex.

Male.—Length, about 3.5 millimeters; wing, 4 to 4.2.

Rostrum and basal segments of palpi yellow, the outer palpal segments blackened. Antennæ with the scape and pedicel obscure yellow; flagellum pale brown; flagellar segments cylindrical, becoming more elongate outwardly; verticils of basal segments much exceeding the segments in length. Head brown.

Mesonotal præscutum yellowish brown, darker near the suture; posterior sclerites of mesonotum pale brown. Pleura yellow, with a conspicuous black spot on the pteropleurite. Halteres yellow. Legs with the coxæ and trochanters yellow; remainder of legs light yellow, only the terminal tarsal segments infuscated. Wings (Plate 1, fig. 9) light yellow, the costal region slightly more saturated; veins yellow. Macrotrichia of veins relatively sparse, there being none on either the first or second section of vein M_{1+2} and only one or two at extreme outer end of Rs. Venation: Sc_1 ending about opposite one-fourth the length of Rs; anterior branch of Rs short, diverging widely from the posterior branch, subequal in length to Rs; cell R_2 at margin about one-third as extensive as cell R_4.

Abdomen, including hypopygium, yellow; lateral margins of segments infuscated; in male, a blackened ring on segments eight and nine. Male hypopygium (Plate 3, fig. 32) with the basistyle, *b*, unarmed with tubercles. Outer dististyle, *od*, entirely blackened, the outer margin with five or six powerful, erect, curved spines, the apex of style broadly flattened and produced into many acute teeth and spines of various sizes. Ædeagus, *a*, relatively short, deeply trifid, the ends of the three arms a little expanded and truncated.

MINDANAO, Davao, district, Calian, Mount Apo, Baroring River (*Clagg*); holotype, male, altitude 6,000 feet, November 10, 1930; paratypes, 2 males, altitude 7,000 feet, November 8 and 9, 1930.

Atarba (*Atarbodes*) *apoensis* is very distinct from all regional species of the genus. The group of Formosan and Japanese *Atarbodes* have the venation of the radial field entirely different, the branches of Rs extending generally parallel to one another to the margin, cells R_2 and R_4 at margin being subequal or with R_2 more extensive than cell R_4. In venation, the present species is closer to *A.* (*A.*) *argentata* Edwards (Federated Malay States) which has a somewhat similar arrangement of wing veins in the radial field but a very different hypopygium. The deeply trifid ædeagus of *apoensis* is very different from the condition existing in the other regional species known to me. The condition is suggested in *A.* (*A.*) *fuscicornis* Edwards (Formosa), but in the present species the incisions are much deeper. In the single genus *Atarba*, species occur that have the ædeagus simple, profoundly bifurcate, and deeply trifurcate, an unusual range to occur within the limits of a single restricted group. The genus and subgenus are new to the Philippine fauna.

ERIOCERA (ERIOCERA) VITTULA sp. nov. Plate 1, fig. 10.

Allied to *vittipennis;* mesonotum light gray, the præscutum with four black stripes; antennal flagellum and legs chiefly obscure yellow; wings whitish, heavily streaked with brown, the latter color appearing as darkened seams to the veins.

Female.—Length, about 19 millimeters; wing, 14.

Rostrum black, gray pruinose; palpi brownish black. Antennæ with the scape light gray; pedicel and basal four segments of flagellum yellow, the outer four or five segments brown. Head light gray, with long coarse black setæ.

Pronotum dark gray. Mesonotum light gray, the præscutum with four conspicuous black stripes, the intermediate pair separated by a space more than one-half as wide as the stripe itself; lateral stripes nearly one-half as long as the intermediates, not crossing the suture; scutum gray, conspicuously marked with black; scutellum chiefly black, the caudal margin and a capillary median vitta more grayish; postnotum gray. Pleura gray, variegated with blackish. Halteres blackened. Legs with coxæ gray; trochanters brownish black; femora and tibiæ obscure yellow, very narrowly tipped with dark brown; all tarsal segments obscure yellow, the tips narrowly darkened; legs conspicuously hairy. Wings (Plate 1, fig. 10) with the ground color whitish, the veins conspicuously bordered with dark brown to produce a streaked appearance, almost as in *vittipennis.* Costal fringe abundant and conspicuous. Venation: Humeral crossvein oblique; R_2 oblique, directed basad, subequal to or shorter than R_{2+3}; basal section of R_5 about one-half Rs.

Abdominal tergites blackened medially, the basal lateral portions of the individual segments heavily light gray pruinose; rufous-orange areas on sides of segments two and three before the caudal margin; basal sternites yellow, the outer segments gray, margined caudally with dark brown; ovipositor with the genital shield deep orange, the elongate valves orange-horn colored.

MINDANAO, Davao district, Calian, Mount Apo, Galog River trail, altitude 5,000 to 6,000 feet, November 13, 1930 (*Clagg*); holotype, female.

Although this fly is closely allied to *Eriocera vittipennis* Alexander (Mindanao), I must regard it as being distinct, differing in the larger size, the more-extensive yellow coloration of the antennal flagellum, the obscure yellow femora and tibiæ, and the details of venation, especially the position of R_2 and the greater

depth of the radial cells. The venation of *vittipennis* is shown (Plate 1, fig. 11) for comparison.

ERIOCERA (ERIOCERA) DIGNITOSA sp. nov. Plate 1, fig. 12.

Male.—Length, about 22 millimeters; wing, 23.5.

Very closely allied to *E. mindanaoensis* Alexander (Mindanao, Bukidnon Subprovince), differing especially in the larger size and details of venation.

Legs black. Wings (Plate 1, fig. 12) strongly suffused with dark brown, more intense than in *mindanaoensis*, especially in the costal region. Costal fringe very short but dense. Venation: Humeral crossvein transverse; R_{2+3+4} long, exceeding one-half of Rs. *Eriocera mindanaoensis* has R_{2+3+4} about two-fifths the length of Rs (Plate 1, fig. 13).

MINDANAO, Davao district, Calian, Sibulan Barrio, altitude 2,000 feet, October 8, 1930 (*Clagg*) holotype, male.

Genus GONOMYIA Meigen

Gonomyia MEIGEN, Syst. Beschreib. Europ. Dipt. 1 (1818) 146.
Goniomyia OSTEN SACKEN, Mon. Dipt. North America 4 (1869) 177.

The rather numerous species of *Gonomyia* now known from the Philippines fall in five subgenera, the largest being *Lipophleps*. The following key to these species is based essentially on male characters.

Key to the Philippine species of Gonomyia Meigen.

1. Cell R_3 of wings lacking .... 2.
   Cell R_3 of wings present .... 14.
2. Cell 1st M_2 open by atrophy of basal section of M_3, cell 2d M_2 very small; antennal verticils (male) short. (Subgenus *Ptilostenodes* Alexander.) (Luzon.) .... *ptilostenella* Alexander.
   Cell 1st M_2 closed; antennal verticils (male) long and conspicuous. (Subgenus *Lipophleps* Bergroth, partim.) .... 3.
3. Wings with Sc long, Sc_1 ending opposite from one-third to two-fifths the length of Rs (*skusei* group) .... 4.
   Wings with Sc short, Sc_1 ending opposite or before the origin of Rs.. 7.
4. Male hypopygium with two dististyles, the outer a very long, slender, chitinized rod. (Mindanao.) .... *sagittifera* Alexander.
   Male hypopygium with a single, entirely fleshy dististyle .... 5.
5. Male hypopygium with the ædeagus dilated and bearing a comblike row of small chitinized spines. (Mindanao.) *acanthophallus* Alexander.
   Male hypopygium without such armature of the ædeagus .... 6.
6. Male hypopygium with the dististyle and outer lobe of basistyle relatively short and stout, less than one-half the length of the remainder of basistyle; phallosome terminating in five free points. (Luzon.) *longiradialis* Alexander.

Male hypopygium with the dististyle and outer lobe of basistyle long and slender, subequal in length to the remainder of basistyle; phallosome compact, without free blackened points. (Mindanao.) *macilenta* sp. nov.

7. Wings unmarked, except for the stigmal area when this is present.... 8.
   Wings spotted or clouded with darker areas, in addition to the stigmal spot .... 11.
8. Legs uniformly dark brown; male hypopygium with a single, subterminal dististyle .... 9.
   Legs pale, the femora with a conspicuous black terminal or subterminal ring; male hypopygium with three dististyles that are terminal in position, or nearly so .... 10.
9. Male hypopygium with the dististyle heavily sclerotized and blackened, unequally bispinous. (Luzon; British India to Japan.) *incompleta* Brunetti.
   Male hypopygium with the outer dististyle small, simple, entirely fleshy. (Luzon.) .... *maquilingia* Alexander.
10. Male hypopygium with the outer dististyle simple; innermost dististyle produced into three acute blackened points. (Mindanao and Luzon.) *alboannulata* Alexander.
   Male hypopygium with the outer dististyle unequally bifid; innermost dististyle simple, entirely pale. (Mindanao.)........ *discreta* sp. nov.
11. Wings with three major dark costal areas, placed at origin of Rs, at stigma, and at tip of R_{1+2}; male hypopygium with three dististyles, all simple, the innermost shortest and entirely pale. (Mindanao.) .... *tristigmata* sp. nov.
   Wings not patterned as above; male hypopygium with two dististyles; or when with three (*bicolorata*), the outermost style branched on basal half, the innermost nearly as long, at apex drawn out into a long straight spine .... 12.
12. Wings heavily and almost uniformly clouded with brown, the costal region conspicuously pale; Sc very short, Sc_1 ending nearly its own length before the origin of Rs; male hypopygium with three dististyles. (Luzon.) .... *bicolorata* Alexander.
   Wings not so patterned, the darkened areas appearing as spots or seams along cord; Sc_1 ending only a short distance before origin of Rs; male hypopygium with two dististyles........ 13.
13. Wings with a conspicuous dark pattern, including a major area at near midlength of cell R, in addition to the usual clouding along the cord, the dark pattern about as deep and intense as the stigmal area; male hypopygium with the outer dististyle a powerful blackened rod, bifid at extreme tip, inner dististyle entirely pale. (Luzon.) .... *secreta* Alexander.
   Wing pattern very diffuse, appearing as scarcely indicated darkenings along cord and elsewhere on wing disk, this pattern much paler than the stigmal area; male hypopygium with the outer dististyle slender, bearing an acute spine on basal third; apex of inner dististyle an erect to slightly recurved black spine. (Mindanao.) *luteimarginata* Alexander.

14. Cell R_1 of wings very small, vein R_3 nearly perpendicular; cell R_2 at margin fully as wide as cell R_3. (Subgenus *Lipophleps* Bergroth, partim.) (Luzon.) .... *pallidisignata* Alexander.
 Cell R_3 very extensive, at wing margin fully three or four times as wide as cell R_2.. 15.
15. Cell 1st M_2 closed. (Subgenus *Gonomyia* Meigen.) (Mindanao.) *nebulicola* sp. nov.
 Cell 1st M_2 open by atrophy of basal section of M_3.................................. 16.
16. Wings with m-cu at or beyond the fork of M. (Subgenus *Progonomyia* Alexander.) (Mindanao.) .... *terebrella* Alexander.
 Wings with m-cu more than its own length before the fork of M. (Subgenus *Ptilostena* Bergroth.)... 17.
17. Wings unmarked, except for the stigmal area; Sc short, Sc_1 ending opposite origin of Rs; cell R_3 small, on margin shorter than cell R_4 and only a little more extensive than cell R_2. (Negros and Java.) *metatarsata* de Meijere.
 Wings spotted with brown, including areas at origin of Rs, tip of vein R_4, and along cord; Sc longer, Sc_1 ending about opposite one-third the length of Rs; cell R_3 on margin very extensive, much exceeding cell R_4; cell R_2 almost closed on margin by approximation of veins R_{1+2} and R_3. (Mindanao, Buru, and North Borneo.) *punctipennis* Edwards.

The various references given herewith in conjunction with the different species of *Gonomyia* (and also of the genera *Erioptera* and *Molophilus*, later in this same report) pertain to exact distributional records for the Philippines rather than to the original descriptions of the various species.

PHILIPPINE SPECIES OF THE SUBGENUS PTILOSTENODES

Ptilostenodes Alexander.[8] One Philippine species.

Gonomyia (*Ptilostenodes*) *ptilostenella* Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. 45 (1931) 441–442.

The various species of *Ptilostenodes* are all Oriental, ranging from Formosa to Java.

PHILIPPINE SPECIES OF THE SUBGENUS LIPOPHLEPS

Lipophleps Bergroth. The numerous species of this subgenus in the Philippines are not safely to be determined except by a careful study of the male genitalic characters, which here offer unusually strong characters for the separation of otherwise similar species.

Gonomyia (*Lipophleps*) *acanthophallus* Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. 45 (1931) 442–443.

[8] Arch. für Hydrobiol., Suppl. Bd. 9 (1931) 182.

Gonomyia (*Lipophleps*) *alboannulata* Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 31–32.
Gonomyia (*Lipophleps*) *bicolorata* Alexander; ALEXANDER, Philippines, VII, Philip. Journ. Sci. 43 (1930) 295–297.
Gonomyia (*Lipophleps*) *discreta* sp. nov.; this report.
Gonomyia (*Lipophleps*) *incompleta* Brunetti; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 29–30.
Gonomyia (*Lipophleps*) *longiradialis* Alexander; ALEXANDER, Philippines, VI, Philip. Journ. Sci. 41 (1930) 307–308.
Gonomyia (*Lipophleps*) *luteimarginata* Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 32–33.
Gonomyia (*Lipophleps*) *macilenta* sp. nov.; this report.
Gonomyia (*Lipophleps*) *maquilingia* Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 28–29.
Gonomyia (*Lipophleps*) *pallidisignata* Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 30–31.
Gonomyia (*Lipophleps*) *sagittifera* Alexander; ALEXANDER, Philippines, XIV, Philip. Journ. Sci. 48 (1932) 40–41.
Gonomyia (*Lipophleps*) *secreta* Alexander; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 33–34.
Gonomyia (*Lipophleps*) *tristigmata* sp. nov.; this report.

Species of *Lipophleps* abound in most of the faunal areas of the world, excepting the western Palæarctic, being very characteristic of the Oriental and Neotropical Regions, and of the remote islands of the Pacific Ocean.

PHILIPPINE SPECIES OF THE SUBGENUS GONOMYIA

Gonomyia Meigen, s. s. A single species of this widely distributed subgenus has been taken in the Philippines but others will certainly be found to occur there.

Gonomyia (*Gonomyia*) *nebulicola* sp. nov.; this report.

The subgenus is the dominant one in the entire Holarctic Region, with relatively fewer species in the Neotropical, Ethiopian, and Oriental Regions.

PHILIPPINE SPECIES OF THE SUBGENUS PROGONOMYIA

Progonomyia Alexander. As is the case with the last group, a single species has been described from the Philippines but others must exist in this diversified region.

Gonomyia (*Progonomyia*) *terebrella* Alexander; ALEXANDER, Philippines, XI, Philip. Journ. Sci. 46 (1931) 285–286.

The majority of the species of this subgenus occur in the Neotropical and southern Ethiopian Regions, with a few species in the Oriental Region and southern parts of the eastern Palæarctic Region.

PHILIPPINE SPECIES OF THE SUBGENUS PTILOSTENA

Ptilostena Bergroth. Two widely-distributed lowland species have been discovered in the Philippines.

Gonomyia (Ptilostena) metatarsata de Meijere; EDWARDS, Notulae Entomologicae 6 (1926) 37.

Gonomyia (Ptilostena) punctipennis Edwards; ALEXANDER, Philippines, X, Philip. Journ. Sci. 46 (1931) 35.

The subgenus is very characteristic of the Holarctic Region, with a few scattered species in the Ethiopian, Oriental, and Australasian Regions.

GONOMYIA (LIPOPHLEPS) MACILENTA sp. nov. Plate 1, fig. 14; Plate 3, fig. 33.

Belongs to the *skusei* group; general coloration of mesonotum dark brown, the scutellum and cephalic-lateral portions of the postnotal mediotergite yellow; pleura dark brown, with a conspicuous whitish longitudinal stripe; apices of knobs of halteres yellow; legs brownish black; wings with a brownish tinge, the stigma a little darker; Sc_1 ending about opposite two-fifths the length of Rs; male hypopygium with a single dististyle, this subequal in length to the outer lobe of basistyle.

Male.—Length, about 3.3 to 3.5 millimeters; wings, 3.8 to 4.

Rostrum obscure yellow; palpi black. Antennæ black throughout; flagellar segments elongate, with an abundant elongate white pubescence. Head black, gray pruinose, the central portion of the posterior vertex light yellow.

Pronotum and anterior lateral pretergites light yellow. Mesonotum dark brown, the median region of scutum a trifle paler; scutellum chiefly testaceous-yellow; cephalic-lateral angles of postnotal mediotergite yellow. Pleura dark brown, with a conspicuous whitish longitudinal stripe crossing the ventral sclerites. Halteres dusky, the base of stem and apex of knob light yellow. Legs with the fore coxæ pale, the remaining coxæ and all trochanters darkened; remainder of legs brownish black. Wings (Plate 1, fig. 14) with a brownish tinge, the stigmal region darker brown; veins pale brown. Macrotrichia on more than distal half of vein 1st A and on distal fifth of 2d A. Venation: Sc_1 ending about opposite two-fifths the length of Rs, Sc_2 about halfway between origin of Rs and tip of Sc_1; basal section of R_5 short, r-m correspondingly lengthened, gently arcuated; m-cu shortly before fork of M.

Abdominal tergites dark brown, the sternites paler. Male hypopygium (Plate 3, fig. 33) with the outer angle of basistyle,

b, prolonged into a slender lobe. A single dististyle, *d*, that is about as long as the lobe of the basistyle, a little dilated on outer half, terminating in a powerful fasciculate seta, with several smaller setæ on distal half, including one of unusual length on outer face at near three-fourths the length of style. Phallosome, *p*, compact, without free blackened points, as is the case in *longiradialis*, or without a series of acute spines, as in *acanthophallus;* apex of longest lobe ending in a short acute point, provided with several microscopic setulæ.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet, January 29, 1931 (*Clagg*); holotype, male; paratype, male.

Gonomyia (*Lipophleps*) *macilenta* is most nearly allied to *G.* (*L.*) *acanthophallus* Alexander (Mindanao) in its general appearance and venation, differing conspicuously in the structure of the male hypopygium, more especially of the phallosome.

GONOMYIA (LIPOPHLEPS) DISCRETA sp. nov. Plate 1, fig. 15; Plate 3, fig. 34.

General coloration dark brown; thoracic pleura striped longitudinally with dark brown and silvery white; halteres with the knobs dark, the outer third obscure yellow; femora with a dark subterminal ring; wings nearly hyaline, unmarked; male hypopygium with three dististyles, the outer stout, blackened, forked at beyond midlength; middle dististyle a pale tail-like setiferous lobe.

Male.—Length, about 2.8 to 3 millimeters; wing, 3.

Female.—Length, about 4 millimeters; wings, 4.

Rostrum and palpi black. Antennæ with the basal segments light brown, the succeeding three or four segments pale, the outer ones passing to black; flagellar verticils very long. Head badly flexed, apparently uniformly dark gray.

Mesonotum dark brown, the anterior lateral pretergites light yellow; posterior sclerites of mesonotum concealed by mounting medium, the pleurotergite obscure yellow. Pleura chiefly obscure yellow, with a conspicuous longitudinal silvery stripe across the ventral sclerites, this area bordered dorsally and less evidently on ventral edge by brown lines, the more dorsal extending from the propleura to the base of abdomen, passing beneath the halteres; ventral sternopleurite dark brown, pruinose. Halteres yellow, the basal two-thirds of the knob infuscated, the apex restrictedly yellow in male, entirely dark in female. Legs with the fore coxæ narrowly darkened; remaining coxæ and all trochanters pale yellow; femora pale brown, with a darker brown subterminal ring that is preceded and followed by clear

yellow annuli; tibiæ and tarsi pale, the tips of basitarsi and remaining tarsal segments dark brown. Wings (Plate 1, fig. 15) nearly hyaline, the stigma not or scarcely evident; veins pale brown. Costal fringe relatively long and conspicuous; macrotrichia on outer ends of both anal veins. Venation: Sc of moderate length, Sc_1 ending just before origin of Rs, Sc_2 not evident; anterior branch of Rs gently sinuous; m-cu before fork of M; vein 2d A nearly straight to gently convex.

Abdomen chiefly dark brown, the pleural region broadly silvery white; hypopygium dark. In female, caudal margins of tergites narrowly pale yellow. Male hypopygium (Plate 3, fig. 34) with the outer dististyle, *od*, a powerful blackened rod, at just beyond midlength bifid, the outer arm a slender, gently curved spine that narrows to an acute point; inner arm a blunt structure, densely set with obtuse teeth to produce a macelike appearance; besides these small, compact denticles, there is a single outstanding spine. Middle dististyle, *md*, an elongate pale rod, a little expanded on outer half, thence narrowed to a slender apical point, the margin with numerous setæ. Inner dististyle, *id*, shortest, exceeding one-half the middle style, with numerous setæ, including a fasciculate seta near apex.

MINDANAO, Davao district, Libby, December 9, 1930 (*Clagg*); holotype, male; allotype, female; paratype, female.

Gonomyia (*Lipophleps*) *discreta* is very different from other regional species in the structure of the male hypopygium, especially of the outer and middle dististyles. By Edwards's key to the Oriental species of *Lipophleps* [9] the present fly runs out at couplet 4, disagreeing with both included species in the coloration of the body. The structure of the male hypopygium of *G.* (*L.*) *diffusa* (de Meijere) has not been described and is not known to me.

GONOMYIA (LIPOPHLEPS) TRISTIGMATA sp. nov. Plate 1, fig. 16; Plate 3, fig. 35.

General coloration brownish gray; scutellum obscure yellow; pleura chiefly brown, with a conspicuous silvery longitudinal stripe; halteres yellow, the basal half of knob brown; legs chiefly dark brown; wings weakly darkened, the costal region broadly pale, variegated by three large brown spots; male hypopygium with three dististyles.

Male.—Length, about 2.6 to 2.7 millimeters; wing, 3 to 3.2.

Female.—Length, about 3.6 to 3.8 millimeters; wing, 3.8.

[9] Journ. Federated Malay States Mus. 14 (1928) 104–105.

Rostrum and palpi black. Antennæ with the scape yellow above, infuscated on lower face; pedicel yellow; flagellum dark brown. Head chiefly yellow above, darker in the male.

Mesonotum brownish gray, the anterior lateral pretergites very pale yellow; pseudosutural foveæ black; posterior sclerites of mesonotum dark, the scutellum obscure yellow. Pleura with the dorsal region pale brown, the ventral portion chiefly occupied by a conspicuous longitudinal silvery stripe that is bordered both dorsally and ventrally by dark brown. Halteres pale yellow, the basal half of knob brown. Legs with the fore coxæ silvery white, the remaining coxæ and all trochanters brownish testaceous to brown; remainder of legs dark brown, in cases with the extreme tip of femur slightly paler. Wings (Plate 1, fig. 16) with the ground color weakly infuscated, the costal region broadly pale yellow, variegated by three large brown spots, the first placed at tip of Sc and origin of Rs; the second, stigmal, at end of R_1; the last at outer end of anterior branch of Rs; a further paler brown wash in the arcular region; remainder of ground color more or less variegated by slightly darker seams along cord and outer end of cell 1st M_2. Costal fringe (male) long and conspicuous; vein 1st A without macrotrichia; vein 2d A with only one or two near outer end. Venation: Sc_1 ending about opposite or just beyond origin of Rs; basal section of R_5 long, exceeding m; m-cu just before fork of M; vein 2d A gently sinuous.

Abdominal tergites brown, variegated at caudal-lateral angles by obscure yellow, the caudal margins more narrowly pale; sternites brown, the caudal margins pale; hypopygium chiefly dark colored. Male hypopygium (Plate 3, fig. 35) with three dististyles, the outer, *od*, longest, a slender blackened rod that is narrowed to a nearly acute tip, at near midlength on inner face, with an expanded darkened flange. Second style, *md*, a simple rod that is about two-thirds the length of the first, narrowed to an acute point, the distal half blackened. Inner style, *id*, a slender fingerlike pale lobe, the outer half with several punctures, at apex with two fasciculate setæ. Phallosome, *p*, consisting of two slender, gently diverging rods, the tips acute. Ædeagus at apex curved into a crook.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet (*Clagg*); holotype, male, January 1, 1931; allotype, female, December 29, 1930; paratypes, 5 males and females, December 29, 1930 to January 1, 1931.

Gonomyia (*Lipophleps*) *tristigmata* is readily distinguished by the conspicuous wing pattern and the structure of the male hypopygium. By Edwards's key to the Oriental species of the subgenus [10] the present fly runs to *G.* (*L.*) *hackeri* Edwards, which has a very different male hypopygium.

GONOMYIA (GONOMYIA) NEBULICOLA sp. nov. Plate 1, fig. 17; Plate 3, fig. 36.

General coloration of mesonotum brownish gray, the scutellum yellow; rostrum obscure yellow, antennæ black throughout; pleura yellow, variegated with brown; knobs of halteres slightly brightened; legs black; wings nearly hyaline, the stigma a trifle darker; Sc_1 ending shortly beyond origin of Rs; R_{2+3+4} strongly arcuated; basal section of R_5 short; male hypopygium with the inner dististyle trifid; phallosome asymmetrical.

Male.—Length, about 4 millimeters; wing, 4.5.

Female.—Length, about 5 millimeters; wing, 4.7 to 4.8.

Rostrum obscure yellow; palpi black. Antennæ black throughout; flagellar segments long-oval, decreasing in size outwardly. Head light gray.

Pronotum and anterior lateral pretergites yellow. Mesonotum brownish gray, the humeral region of præscutum restrictedly obscure yellow; pseudosutural fovæ black; median region of scutum and the broad scutellum obscure yellow. Pleura obscure yellow, variegated on anepisternum with dark brown, on the ventral sternopleurite with reddish brown. Halteres dusky, the base of stem and apex of knobs a little brighter. Legs with the fore coxæ weakly darkened, the remaining coxæ more yellow; trochanters brownish yellow; remainder of legs black. Wings (Plate 1, fig. 17) nearly hyaline, the oval stigma a little darker than the ground color; veins brownish black. Costal fringe relatively long and conspicuous. Venation: Sc_1 ending shortly beyond origin of Rs, in cases to opposite one-fifth the length of the latter vein; Sc_2 not far from tip of Sc_1; R_{2+3+4} strongly arcuated; basal section of R_5 short, r-m correspondingly lengthened; m-cu at or very close to fork of M.

Abdominal tergites dark brown, the sternites more yellowish brown; hypopygium dark. Male hypopygium (Plate 3, fig. 36) with the basistyle, *b*, relatively long and slender, with a short apical lobe. Outer dististyle, *od*, fleshy, setiferous. Inner dististyle, *id*, trifid, its outermost arm a strongly curved spine, the central portion a more nearly straight spine; outer portion of

[10] Loc. cit.

inner dististyle with conspicuous setæ. Phallosome, *p*, asymmetrical, the ædeagus being subtended by one long black sinuous spine.

MINDANAO, Davao district, Calian, Mount Apo, Galog River, altitude 6,000 feet, October 16, 1930 (*Clagg*); holotype, male; allotype, female, October 18, 1930; paratypes, several of both sexes, chiefly females, altitude 6,000 feet, September 13, October 10, 12, 16, and 25, November 3 and 4, 1930; 1 male, 1 female, La Lun Mountains, altitude 5,500 feet, December 31, 1930, and January 1, 1931; 1 male, Mount Mayo, altitude 4,000 feet, January 26, 1931.

Gonomyia (*Gonomyia*) *nebulicola* is the first species of the subgenus to be recorded from the Philippines. It is distinguished from *G.* (*G.*) *affinis* Brunetti (British India) and *G.* (*G.*) *bryanti* Alexander (Java) by the strongly arcuate R_{2+3+4}. It is further distinguished from *bryanti* by the structure of the inner dististyle of the male hypopygium, and from the Bornean *G.* (*G.*) *symmetrica* Edwards, by the very different male hypopygium.

Genus ERIOPTERA Meigen

Erioptera MEIGEN, Illiger's Magaz. 2 (1803) 262.

The various Philippine species of *Erioptera* may be separated by means of the following key, which is based in part on male characters.

Key to the Philippine species of Erioptera Meigen.

1. Cell R_3 relatively shallow, vein R_2 lying far before its inner end, vein R_{3+4} thus being present as a distinct element. (Subgenus *Empeda* Osten Sacken.) .... 2.
   Cell R_3 deep, vein R_2 connecting with R_{2+3} beyond the inner end of cell R_3, vein R_{2+3} thus being present as a distinct element.......... 4.
2. Femora uniformly darkened on distal half or more; general coloration of mesonotum light brown, paling to gray on sides. (Mindanao.) .... *lunensis* Alexander.
   Femora yellow, narrowly and abruptly tipped with black; general coloration of thorax black .... 3.
3. Humeral region of præscutum with a conspicuous yellow triangular area; R_{3+4} longer than R_4; male hypopygium with the outer dististyle blackened, the arms slender. (Mindanao.).......... *rata* sp. nov.
   Mesonotal præscutum uniformly blackened; R_{3+4} shorter than R_4; male hypopygium with the outer dististyle entirely pale, the arms expanded at outer ends. (Mindanao.).......... *perrata* sp. nov.
4. Cell 1st M_2 closed. (Subgenus *Ilisia* Rondani.).......... 5.
   Cell 1st M_2 open by the atrophy of m.......... 6.

5. General coloration of thorax gray, variegated with velvety black, especially on lateral portions; femora chiefly darkened, ringed with yellow, the extreme tip pale; wings pale, with an ocellate dark pattern, the numerous marginal areas paler medially, bordered with brown; vein Sc_2 just before the fork of Rs. (Oriental Region; Mindanao.) .... *fenestrata* (re Meijere).
   General coloration of thorax reddish yellow, the posterior sclerites of mesonotum and a dorsal stripe on pleura dark brown; legs yellow, the tips of femora narrowly to insensibly darkened; wings pale, with a more-restricted, solidly darkened pattern; Sc_2 just beyond origin of Rs. (Mindanao.) .... *perpictula* Alexander.
6. Apical cells of wing very deep, the cord lying at or before midlength of wing; vein 2d A only slightly sinuous. (Subgenus *Teleneura* Alexander.) .... 7.
   Apical cells of wing shallower, the cord lying at from three-fifths to two-thirds the length of wing; vein 2d A very strongly sinuous, with nearly the distal half extending parallel to caudal margin of wing. (Subgenus *Erioptera* Meigen.) .... 9.
7. Wings with a heavy, pale brown pattern; femora with about the basal half darkened, the apical portion broadly light yellow. (Oriental Region; Mindanao.) .... *nigribasis* Edwards.
   Wings uniformly suffused with darker, immaculate; legs uniformly darkened .... 8.
8. General coloration of præscutum dark brown to black, the thoracic pleura concolorous. (Oriental Region; Mindanao.)
   fusca de Meijere.
   General coloration of præscutum light brown, paling to yellow on margins; thoracic pleura with a conspicuous, brownish black, longitudinal stripe. (Mindanao and Luzon.) .... *melanotænia* Alexander.
9. Wings with a saturated grayish yellow suffusion, the costal cell whitish; no darkened seam along cord; some of veins narrowly bordered with yellow. (Luzon.) .... *rubripes* Alexander.
   Wings pale, with a faint infuscate cloud along cord, darkening the veins and adjoining membrane; no brightening of membrane adjoining the veins .... 10.
10. Male hypopygium with the outer dististyle bifid, its outer arm an acute spine, the inner arm a rounded capitate head. (Philippines.)
   luzonica Alexander.
   Male hypopygium with the outer dististyle a simple, blackened rod.. 11.
11. Male hypopygium with the inner dististyle a flattened, oval blade bearing an acute spine on outer margin; gonapophyses obtuse and weakly bifid at tips. (Mindanao.) .... *lunicola* sp. nov.
   Male hypopygium with the inner dististyle a slender rod, without spines, at apex dilated into a weak head; gonapophyses appearing as acute spines. (Mindanao.) .... *alta* sp. nov.

PHILIPPINE SPECIES OF THE SUBGENUS EMPEDA

Empeda Osten Sacken. Besides the two species described herewith, a single species had been recorded from the Philip-

pines. Species of this subgenus will surely be found to occur in the mountains of Luzon.

Erioptera (*Empeda*) *lunensis* Alexander; ALEXANDER, Philippines, XI, Philip. Journn. Sci. 46 (1931) 288–289.

Most of the species of *Empeda* occur in the Holarctic and northern Neotropical and Oriental Regions. A very few others are found in the Ethiopian and Australasian Regions.

PHILIPPINE SPECIES OF THE SUBGENUS ILISIA

Ilisia Rondani. I am very doubtful as to whether *perpictula* can be correctly referred to this subgenus, since the male hypopygium is very different from that of the typical form. *Erioptera fenestrata* is a perfectly typical member of *Ilisia*.

Erioptera (*Ilisia*) *fenestrata* (de Meijere); this report.
Erioptera (*Ilisia*) *perpictula* Alexander; ALEXANDER, Philippines, IX, Philip. Journ. Sci. 45 (1931) 443–444.

The species of *Ilisia* are all Holarctic, with the exception of a few species occurring in Formosa and the Malayan islands.

PHILIPPINE SPECIES OF THE SUBGENUS TELENEURA

Teleneura Alexander. Three species are now known from the Islands.

Erioptera (*Telencura*) *nigribasis* Edwards; this report.
Erioptera (*Teleneura*) *fusca* de Meijere; ALEXANDER, Philippines, XI. Philip. Journ. Sci. 46 (1931) 287.
Erioptera (*Teleneura*) *melanotaenia* Alexander; ALEXANDER, Philippines, XI, Philip. Journ. Sci. 46 (1931) 287–288.

All known species of the subgenus are Oriental.

PHILIPPINE SPECIES OF THE SUBGENUS ERIOPTERA

Erioptera Meigen, s. s. To the four species recorded herewith, numerous additions will probably be made as further collections are taken in the mountains of the major islands of the group.

Erioptera (*Erioptera*) *alta* sp. nov.; this report.
Erioptera (*Erioptera*) *lunicola* sp. nov.; this report.
Erioptera (*Erioptera*) *luzonica* Alexander; this report.
Erioptera (*Erioptera*) *rubripes* Alexander; ALEXANDER, Philippines, VIII, Philip. Journ. Sci. 45 (1931) 287–288.

Species of the typical subgenus *Erioptera* are found in all major regions of the World.

ERIOPTERA (EMPEDA) RATA sp. nov. Plate 3, fig. 38.

Mesonotal præscutum almost covered by three confluent black stripes, leaving the humeral region obscure yellow; tips of femora narrowly blackened; wings grayish subhyaline, the stigma distinct; male hypopygium with the outer dististyle heavily blackened, the arms slender.

Male.—Length, about 3 millimeters; wing, 4.

Female.—Length, about 3.5 millimeters; wing, 4.

Rostrum dark; palpi chiefly yellowish brown. Antennæ with the scape and pedicel black; flagellar segments pale brown, the outer segments darker; flagellar segments subglobular to short-oval, the outer segments more elongate-oval; verticils of moderate length only. Head light gray.

Pronotum and anterior lateral pretergites yellow. Mesonotal præscutum almost covered by three, confluent, shiny, black stripes, only the humeral triangles reddish yellow; scutum black, a trifle pruinose; scutellum grayish black basally, the margin obscure reddish; postnotal mediotergite black, sparsely pruinose. Pleura yellow, conspicuously variegated with dark gray, the latter areas including the anepisternum, ventral sternopleurite, and most of the pleurotergite; dorsopleural region and ventral sternopleurite of the ground color. Halteres yellow. Legs with the fore coxæ brownish black; remaining coxæ and trochanters yellow; femora, tibiæ, and basitarsi yellow, the tips narrowly but conspicuously blackened; remainder of tarsi black. Wings grayish subhyaline, the prearcular region and costal margin a trifle more yellowish; stigma pale brown but distinct; veins pale brown, paler in costal region. Venation: Sc_1 ending about opposite one-fifth the length of Rs; R_{3+4} longer than R_4.

Abdominal tergites dark brown; sternites yellow; hypopygium chiefly reddish brown. In female, the abdominal tergites, especially the outer ones, narrowly ringed caudally with obscure yellow. Male hypopygium (Plate 3, fig. 38) with the outer dististyle, *od*, entirely blackened, both arms slender, subequal to or a trifle longer than the stem. Inner dististyle, *id*, dilated at outer end into a spatula that is provided with rather numerous setulæ.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, December 29, 1930 (*Clagg*); holotype, male; allotype, female.

Most nearly allied to *Erioptera* (*Empeda*) *nigroapicalis* Alexander (Formosa) in the large size, pattern of legs, and heavily

blackened dististyles of the male hypopygium, differing in the confluent black pattern of the mesonotal præscutum, the heavily darkened pleura, and details of the wing venation and pattern, especially the shorter apical forks and the distinct stigmal area. In its blackened thoracic pattern, the present fly is similar to *E.* (*E.*) *perrata* sp. nov., differing in the heavily blackened outer dististyle of the male hypopygium.

ERIOPTERA (EMPEDA) PERRATA sp. nov. Plate 1, fig. 18; Plate 3, fig. 39.

Male.—Length, about 2.3 millimeters; wing, 3.

Closely allied to *E.* (*E.*) *rata* sp. nov., differing especially in the small size, uniformly darkened thorax, and pale styli of the male hypopygium.

Palpi entirely black. Mesonotal præscutum entirely black, without brightening at the humeri; remainder of mesonotum black, sparsely pruinose, the caudal margin of scutellum a trifle brightened. Pleura brownish black, the dorsal sternopleurite somewhat more intense; dorsopleural region yellow. Wings (Plate 1, fig. 18) without an evident stigmal area. Venation: R_{3+4} longer than R_3 but shorter than R_4. Abdominal tergites dark brown, the sternites and hypopygium more yellowish. Male hypopygium (Plate 3, fig. 39) with the dististyles entirely pale, the outer, *od*, deeply divided, its inner arm a broadly flattened spatula. Inner dististyle, *id*, a flattened blade, gradually widened distally, the apex obtusely rounded, provided with a few microscopic setulæ.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, January 1, 1931 (*Clagg*); holotype, male; paratype, 1 broken specimen, sex uncertain; 1 male, Mount Apo, Galog River, altitude 6,000 feet, October 16, 1930 (*Clagg*).

The present fly is very similar to the Japanese and Formosan *Erioptera* (*Empeda*) *minuscula* Alexander, in the pale dististyles of the male hypopygium, in conjunction with the small size and leg pattern, differing most evidently in the uniformly blackened mesonotum.

ERIOPTERA (ILISIA) FENESTRATA (de Meijere). Plate 3, fig. 37.

> *Acyphona fenestrata* DE MEIJERE, Tijd. voor Entomol. 56 (1913) 352–353, pl. 17, fig. 19 (wing).

Described from Java, later recorded by Edwards from the Malay Peninsula and Borneo. MINDANAO, Davao district, Calian, Mount Apo, altitude 6,000 feet, October 16 to November 3, 1930 (*Clagg*); several of both sexes.

The distinctive male hypopygium (Plate 3, fig. 37) has not been described hitherto. Outer dististyle, *od*, unusually slender. Ædeagus short, subtended by the blackened horns of the gonapophyses, *g*.

ERIOPTERA (TELENEURA) NIGRIBASIS Edwards.

Erioptera nigribasis EDWARDS, Journ. Federated Malay States Mus. 14 (1928) 99–100, pl. 1, fig. 8 (wing).

Known hitherto only from Pahang and Borneo. MINDANAO, Davao district, Calian, Mount Apo, Sibulan River, altitude 5,000 to 6,000 feet, August 29 and October 18 to 20, 1930; Mainit River, altitude 6,000 feet, September 9, 1930 (*Clagg*).

ERIOPTERA (ERIOPTERA) LUZONICA Alexander.

Erioptera (Erioptera) luzonica ALEXANDER, Insec. Inscit. Menst. 5 (1917) 7–8.

Described from Luzon. Since taken at Badajoz, Tablas, August 28, 1928 (*Rivera and Duyag*). The fly is very closely allied to *E.* (*E.*) *notata* de Meijere,[11] differing especially in slight details of structure of the male hypopygium, notably of the outer dististyle and the gonapophyses.

ERIOPTERA (ERIOPTERA) ALTA sp. nov. Plate 1, fig. 19; Plate 3, fig. 40.

General coloration pale yellow, including the thoracic pleura; knobs of halteres weakly darkened; wings yellow, the veins of the cord darker; male hypopygium with the outer dististyle a little dilated on inner margin at near midlength; inner dististyle at apex expanded into a disklike head; gonapophyses appearing as blackened horns.

Male.—Length, about 3.5 to 4.5 millimeters; wing, 4 to 5.

Female.—Length, about 5 to 5.3 millimeters; wing, 6 to 6.2.

Rostrum pale brown, the palpi dusky. Antennæ with the scape and pedicel brown, the basal three or four segments of the flagellum light yellow; remaining flagellar segments brown, long-oval. Head yellow, the anterior vertex more whitish.

Anterior lateral pretergites whitish. Mesonotum yellow, the pseudosutural foveæ and tuberculate pits pale. Pleura pale yellow. Halteres yellow, the knobs weakly infuscated. Legs with the coxæ and trochanters pale yellow; remainder of legs yellow, the outer tarsal segments darkened. Wings (Plate 1, fig. 19) yellow, including the veins; cord pale brown; macro-

[11] Tijd. voor Entomol. 54 (1911) 46.

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trichia of veins long and pale. Costal fringe long. Venation: Vein 2d A very strongly sinuous.

Abdominal tergites light brown; sternites similar, the margins of the segments restrictedly yellow; hypopygium yellow. Male hypopygium (Plate 3, fig. 40) with the outer dististyle, *od*, slightly dilated on inner margin at near midlength, the tip blackened and gently curved. Inner dististyle, *id*, shorter, more capitate at apex. Gonapophyses, *g*, appearing as simple, gently curved, blackened horns.

MINDANAO, Davao district, Calian, Mount Apo, Lino Lake, altitude 8,000 feet, September 19, 1930 (*Clagg*); holotype, male; allotype, female; paratypes, 5 of both sexes.

Erioptera (*Erioptera*) *alta* is most nearly allied to *E.* (*E.*) *lunicola* sp. nov., differing conspicuously in the structure of the male hypopygium.

ERIOPTERA (ERIOPTERA) LUNICOLA sp. nov. Plate 3, fig. 41.

General coloration testaceous yellow, including the pleura; knobs of halteres dark brown; legs yellow; wings tinged with pale yellow, with a small darkened cloud on anterior cord; male hypopygium with the outer dististyle a simple blackened paddle-like blade; inner dististyle with an acute spine on outer margin near base; gonapophyses blunt and irregularly toothed at tips.

Male.—Length, about 3.5 millimeters; wing, 4.

Rostrum pale; palpi darkened. Antennæ with the basal segments pale yellow, the flagellum brown; flagellar segments oval, with a dense white pubescence and slightly longer verticils. Head yellow.

Mesonotum almost uniformly testaceous-yellow, the lateral margins of the præscutum paler; pseudosutural foveæ and tuberculate pits more reddish. Pleura pale brownish yellow to testaceous-yellow. Halteres pale yellow, the knobs dark brown. Legs with the coxæ and trochanters yellow; remainder of legs yellow, only the terminal two tarsal segments infuscated. Wings with a pale yellow tinge, the base and costal region clearer yellow; a restricted dark cloud on anterior cord, this coloring involving the veins; veins pale yellow. Venation as in the subgenus; vein 2d A very strongly sinuate on nearly the distal half.

Abdomen pale brownish yellow. Male hypopygium (Plate 3, fig. 41) with the mesal-apical angle of basistyle, *b*, produced into a stout hairy lobe. Outer dististyle, *od*, a simple, flattened,

paddlelike, blackened blade. Inner dististyle, *id*, appearing as a flattened, mittenlike lobe, bearing an acute black spine on outer margin near base. Gonapophyses, *g*, blunt and weakly toothed at tips. Ædeagus paired.

MINDANAO, Davao district, Calian, La Lun Mountains, altitude 5,500 feet, December 31, 1930 (*Clagg*); holotype, male; paratype, male; Mati, Mount Mayo, altitude 5,000 feet, January 30, 1931 (*Clagg*); paratype, male.

Erioptera (*Erioptera*) *lunicola* is readily told from allied species of the subgenus that have darkened knobs to the halteres and a faint darkened cloud on anterior cord of wings, by the structure of the male hypopygium. Among the regional species, the closest ally appears to be *E.* (*E.*) *alta* sp. nov.

Genus MOLOPHILUS Curtis

Molophilus CURTIS, British Entomology (1833) 444.

All of the known Philippine species of the genus, as indeed, all those known from the Palæarctic Region, belong to the so-called *gracilis* group, as defined by the present writer.[12] The correct definition of the many species can be made only on a critical study of the male hypopygium. The present key will suffice to separate the few species at present known from the Philippines, the characters used being those of the male sex only.

Key to the Philippine species of Molophilus Curtis.

1. Wings with vein 2d A long, ending opposite or beyond midlength of m-cu; wings with a darkened seam along vein Cu and less distinctly on the anterior and posterior cords. (Philippines.) *sirius* Alexander.
   Wings with vein 2d A short, ending before the level of m-cu; wings subhyaline or infumed, but uniform in color .... 2.
2. Antennæ (male) elongate, if bent backward extending to beyond midlength of abdomen; flagellar segments fusiform, with numerous very long erect setæ at near midlength .... 3.
   Antennæ (male) short, if bent backward not or scarcely attaining the wing root; flagellar segments suboval, with sparse scattered verticils and short, inconspicuous setæ .... 5.
3. Male hypopygium with inner dististyle a strongly curved black hook, provided with numerous short setæ on lower face, to produce a roughened appearance. (Mindanao.) .... *hispidulus* sp. nov.
   Male hypopygium with both dististyles slender and entirely smooth.... 4.

[12] Proc. Linn. Soc. New South Wales 54 (1929) 137–144, pl. 5.

4. Male hypopygium with the outer lobe of basistyle terminating in a gently curved elongate blade; inner dististyle about a fifth longer than the outer, heavily blackened on distal fourth. (Mindanao.) *procericornis* Alexander.

   Male hypopygium with the outer lobe of basistyle terminating in a circular flattened disk; inner dististyle about as long as the outer, not blackened. (Luzon.) .... *banahaoensis* Alexander.

5. General coloration of thoracic notum black, the scutellum reddish yellow; male hypopygium with the inner dististyle bearing an erect lateral spine beyond midlength. (Mindanao.)........ *remulsus* sp. nov.

   General coloration of notum brownish gray or grayish brown, the scutellum more testaceous; male hypopygium with the dististyle simple 6.

6. Wings with costal margin concolorous with remainder of disk or nearly so; legs chiefly dark brown, the posterior tibiæ light yellow, the tips narrowly darkened; male hypopygium with a small blackened hook on inner margin of outer lobe of basistyle. (Mindanao.) *mendicus* Alexander.

   Wings with the costal margin clear light yellow, contrasting with remainder of disk; legs brown; male hypopygium without a blackened hook on basistyle. (Luzon.)................................ *tawagensis* Alexander.

PHILIPPINE SPECIES OF THE GENUS MOLOPHILUS

Molophilus banahaoensis Alexander; ALEXANDER, Philippines, XI, Philip. Journ. Sci. 46 (1931) 289-290.
Molophilus hispidulus sp. nov.; this report.
Molophilus mendicus Alexander; this report.
Molophilus procericornis Alexander; ALEXANDER, Philippines, XI, Philip. Journ. Sci. 46 (1931) 290-292.
Molophilus remulsus sp. nov.; this report.
Molophilus sirius Alexander; this report.
Molophilus tawagensis Alexander; ALEXANDER, Philippines, XI, Philip. Journ. Sci. 46 (1931) 293-294.

MOLOPHILUS SIRIUS Alexander.

Molophilus sirius ALEXANDER, Canadian Ent. 47 (1915) 82-83.

Described from one male and one female, labelled only "Philippine Islands, July. F. Casey. Thru Miss Ludlow." No other specimens have been taken in the Islands.

MOLOPHILUS MENDICUS Alexander.

Molophilus mendicus ALEXANDER, Philip. Journ. Sci. 46 (1931) 292-293.

Described from the La Lun Mountains, Mindanao, taken July 3, 1930. An additional male, Davao district, Mati, Mount Mayo, altitude 5,000 feet, January 30, 1931 (*Clagg*), is much better preserved and supplementary notes are here given. The leg pattern is very distinctive.

Fore and middle legs black. Posterior legs with the femora black, only the bases a little paler; tibiæ abruptly light yellow, the tips narrowly darkened; tarsi black. The male hypopygium has the ædeagus long and slender, nearly twice as long as the longest dististyle.

MOLOPHILUS HISPIDULUS sp. nov. Plate 3, fig. 42.

Belongs to the *gracilis* group and subgroup; general coloration light brown, the dorsal thoracic pleura with a conspicuous, dark brown, longitudinal stripe; antennæ (male) elongate; wings with vein 2d A short; male hypopygium with the dorsal lobe of basistyle narrowed to a pale curved point; inner dististyle a blackened curved rod, the lower face with abundant coarse setæ.

Male.—Length, about 4 millimeters; wing, 4.5.

Female.—Length, about 4.5 millimeters; wing, 5.

Rostrum brown; palpi black. Antennæ (male) elongate, if bent backward extending about to one-third the length of abdomen; scape and pedicel light brown, the flagellum black, with the extreme tips of the individual segments a trifle paler; flagellar segments fusiform, the central portion of each provided with very long, conspicuous, erect setæ. Antennæ (female) short. Head yellowish brown.

Mesonotum light brown, the humeral region of præscutum yellow; pseudosutural foveæ darkened; scutellum testaceous; postnotal mediotergite darker brown. Pleura pale yellow, the dorsal pleurites occupied by a broad, dark brown, longitudinal stripe that becomes paler and more diffuse on the ventral pleurotergite. Halteres yellow, the knobs dark brown. Legs with the fore coxæ darkened, the remaining coxæ and all trochanters yellow; remainder of legs brownish yellow, the terminal tarsal segments darkened. Wings with a pale grayish tinge, the base and costal region more yellowish; veins pale brown. Venation: R_2 in approximate alignment with r-m; vein 2d A relatively short, ending just before level of m-cu.

Abdomen brown, the caudal margins of sternites a little paler; hypopygium brownish yellow. Male hypopygium (Plate 3, fig. 42) with the basistyle, *b*, terminating in three distinct lobes, the dorsolateral lobe, *db*, longest, relatively slender, densely setiferous on outer face, at apex narrowed into a pale, glabrous, curved hook; ventral lobe, *vb*, terminating in long retrorse setæ; mesal lobe smallest, pale, at apex with a group of about six

setæ. Two dististyles, the outer, *od*, a slender, sinuous rod, gradually narrowed to an acute point, the apical third blackened. Inner style, *id*, a powerful, blackened rod, arising from an expanded base, strongly curved at midlength, the lower or concave margin densely set with coarse setulæ from enlarged bases.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet, January 28 to 30, 1931 (*Clagg*); holotype, male, allotype, female; paratypes, 1 male, 1 female.

Molophilus hispidulus is most nearly allied to *M. procericornis* Alexander (Mindanao), differing most decisively in the structure of the male hypopygium, notably the hispid inner dististyle.

MOLOPHILUS REMULSUS sp. nov. Plate 1, fig. 20; Plate 3, fig. 43.

Belongs to the *gracilis* group and subgroup; general coloration black, the scutellum reddish yellow; antennæ (male) short; wings strongly tinged with dusky; wings with vein 2d A short; male hypopygium with all lobes of basistyle short and obtuse at tips; two dististyles, the inner one more elongate, narrowed to an acute spinous point, beyond midlength bearing a small erect spine.

Male.—Length, about 3 to 3.8 millimeters; wing, 3.5 to 4.5.

Rostrum and palpi black. Antennæ (male) short, if bent backward not or scarcely attaining the wing root, black throughout; flagellar segments subcylindrical, with coarse verticils that exceed the segments in length. Head black, sparsely pruinose, especially on anterior vertex.

Mesonotum black, the scutellum abruptly reddish yellow. Pleura black, pruinose. Halteres dusky, with golden setæ. Legs with the coxæ black; trochanters brownish black; femora obscure yellow basally, passing to brown on outer half; tibiæ brown to light brown, the tips darker; tarsi dark brown. Wings (Plate 1, fig. 20) with a strong dusky tinge, the base and prearcular region a trifle brighter; veins and macrotrichia darker brown. Venation: R_2 lying a little proximad of level of r-m; vein 2d A short, ending before level of m-cu.

Abdomen, including hypopygium, brownish black. Male hypopygium (Plate 3, fig. 43) with the basistyle, *b*, terminating in three broadly flattened lobes, the mesal one further produced into a small apical tubercle. Outer dististyle, *od*, shorter, a powerful arm that is extended at about a right angle into a more heavily sclerotized, flattened, beaklike portion. Inner

dististyle, *id*, more elongate, stoutest at base, gradually narrowed and curved to the acute tip; just beyond midlength on outer face with a powerful erect black spine; on outer margin, just before apex of style, with two or three microscopic appressed teeth.

MINDANAO, Davao district, Mati, Mount Mayo, altitude 5,000 feet, January 29, 1931 (*Clagg*); holotype, male; Calian, Mount Apo, Sibulan River, altitude 6,000 feet, August 29, 1930 (*Clagg*); paratype, male.

Molophilus remulsus is very different from all described Oriental species of the group in its black coloration, in conjunction with the structure of the male hypopygium.

ILLUSTRATIONS

[Legend: *a*, Ædeagus; *b*, basistyle; *d*, dististyles; *db*, dorsal lobe of basistyle; *dd*, dorsal dististyle; *g*, gonapophysis; *id*, inner dististyle; *md*, middle or second dististyle; *od*, outer dististyle; *p*, phallosome; *s*, sternite; *t*, tergite; *vb*, ventral lobe of basistyle; *vd*, ventral dististyle.]

PLATE 1

FIG. 1. *Pselliophora invenustipes* sp. nov., wing.
2. *Dolichopeza* (*Nesopeza*) *perdita* sp. nov., wing.
3. *Dolichopeza* (*Nesopeza*) *queribunda* sp. nov., wing.
4. *Limonia* (*Libnotes*) *tenuiclava* sp. nov., wing.
5. *Limonia* (*Limonia*) *patula* sp. nov., wing.
6. *Limonia* (*Limonia*) *desiderata* sp. nov., wing.
7. *Limonia* (*Dicranomyia*) *punctulatoides* sp. nov., wing.
8. *Limonia* (*Geranomyia*) *immobilis* sp. nov., wing.
9. *Atarba* (*Atarbodes*) *apoensis* sp. nov., wing.
10. *Eriocera* (*Eriocera*) *vittula* sp. nov., wing.
11. *Eriocera* (*Eriocera*) *vittipennis* Alexander, wing.
12. *Eriocera* (*Eriocera*) *dignitosa* sp. nov., wing.
13. *Eriocera* (*Eriocera*) *mindanaoensis* Alexander, wing.
14. *Gonomyia* (*Lipophleps*) *macilenta* sp. nov., wing.
15. *Gonomyia* (*Lipophleps*) *discreta* sp. nov., wing.
16. *Gonomyia* (*Lipophleps*) *tristigmata* sp. nov., wing.
17. *Gonomyia* (*Gonomyia*) *nebulicola* sp. nov., wing.
18. *Erioptera* (*Empeda*) *perrata* sp. nov., wing.
19. *Erioptera* (*Erioptera*) *alta* sp. nov., wing.
20. *Molophilus remulsus* sp. nov., wing.

PLATE 2

FIG. 21. *Dolichopeza* (*Nesopeza*) *perdita* sp. nov., male hypopygium details.
22. *Dolichopeza* (*Nesopeza*) *queribunda* sp. nov., male hypopygium details.
23. *Dolichopeza* (*Nesopeza*) *ludibunda* sp. nov., male hypopygium details.
24. *Dolichopeza* (*Nesopeza*) *evanida* sp. nov., male hypopygium details.
25. *Dolichopeza* (*Nesopeza*) *pudibunda* sp. nov., male hypopygium details.
26. *Limonia* (*Libnotes*) *tenuiclava* sp. nov., antenna, flagellar segments 1 to 4, 11, and 12.
27. *Limonia* (*Libnotes*) *tenuiclava* sp. nov., male hypopygium.
28. *Limonia* (*Limonia*) *patula* sp. nov., male hypopygium.
29. *Limonia* (*Dicranomyia*) *punctulatoides* sp. nov., male hypopygium.
30. *Limonia* (*Dicranomyia*) *moronis* sp. nov., male hypopygium.
31. *Limonia* (*Geranomyia*) *immobilis* sp. nov., male hypopygium.

PLATE 3

FIG. 32. *Atarba* (*Atarbodes*) *apoensis* sp. nov., male hypopygium.
33. *Gonomyia* (*Lipophleps*) *macilenta* sp. nov., male hypopygium.
34. *Gonomyia* (*Lipophleps*) *discreta* sp. nov., male hypopygium.
35. *Gonomyia* (*Lipophleps*) *tristigmata* sp. nov., male hypopygium.
36. *Gonomyia* (*Gonomyia*) *nebulicola* sp. nov., male hypopygium.
37. *Erioptera* (*Ilisia*) *fenestrata* (de Meijere), male hypopygium.
38. *Erioptera* (*Empeda*) *rata* sp. nov., male hypopygium.
39. *Erioptera* (*Empeda*) *perrata* sp. nov., male hypopygium.
40. *Erioptera* (*Erioptera*) *alta* sp. nov., male hypopygium.
41. *Erioptera* (*Erioptera*) *lunicola* sp. nov., male hypopygium.
42. *Molophilus hispidulus* sp. nov., male hypopygium.
43. *Molophilus remulsus* sp. nov., male hypopygium.

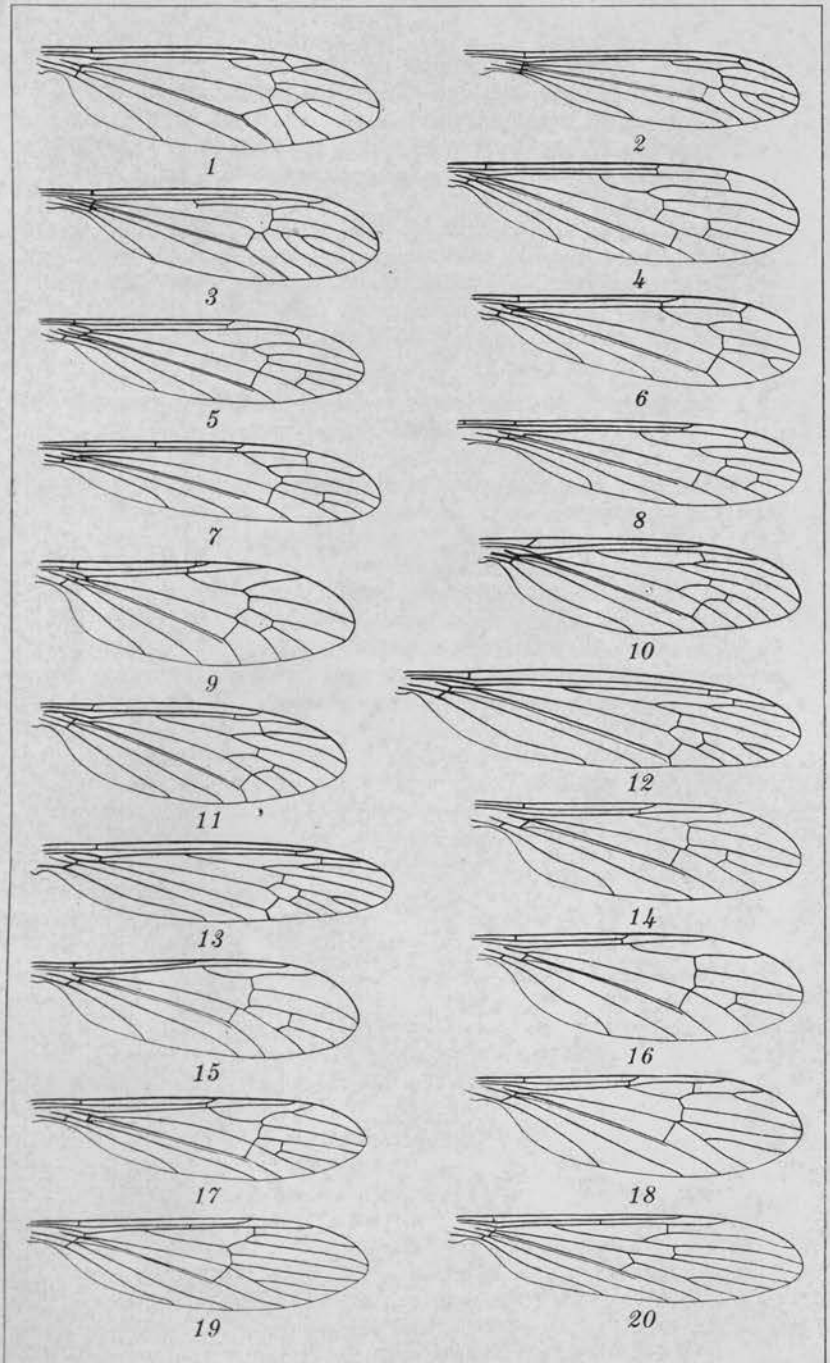

PLATE 1.

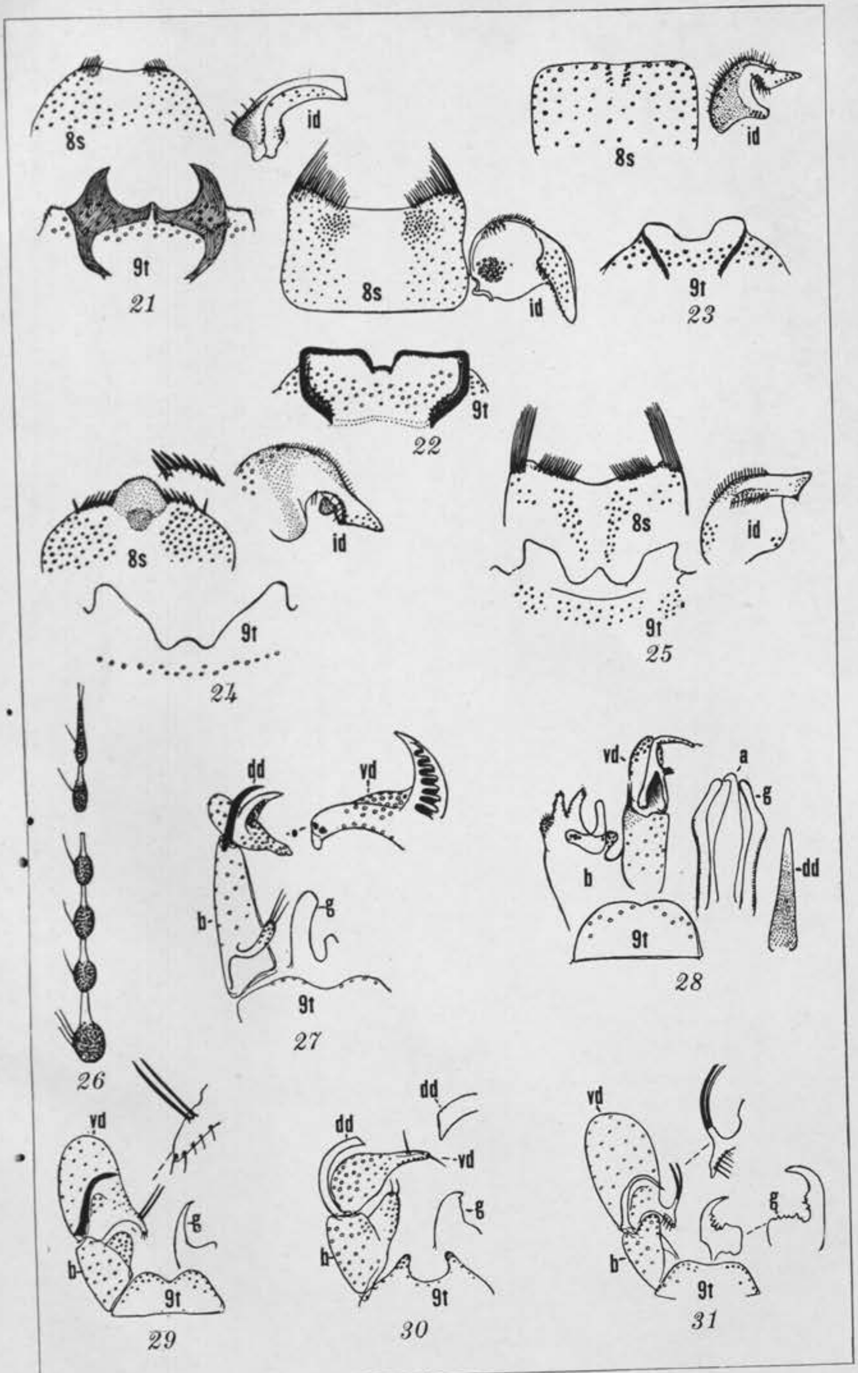
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PLATE 2.

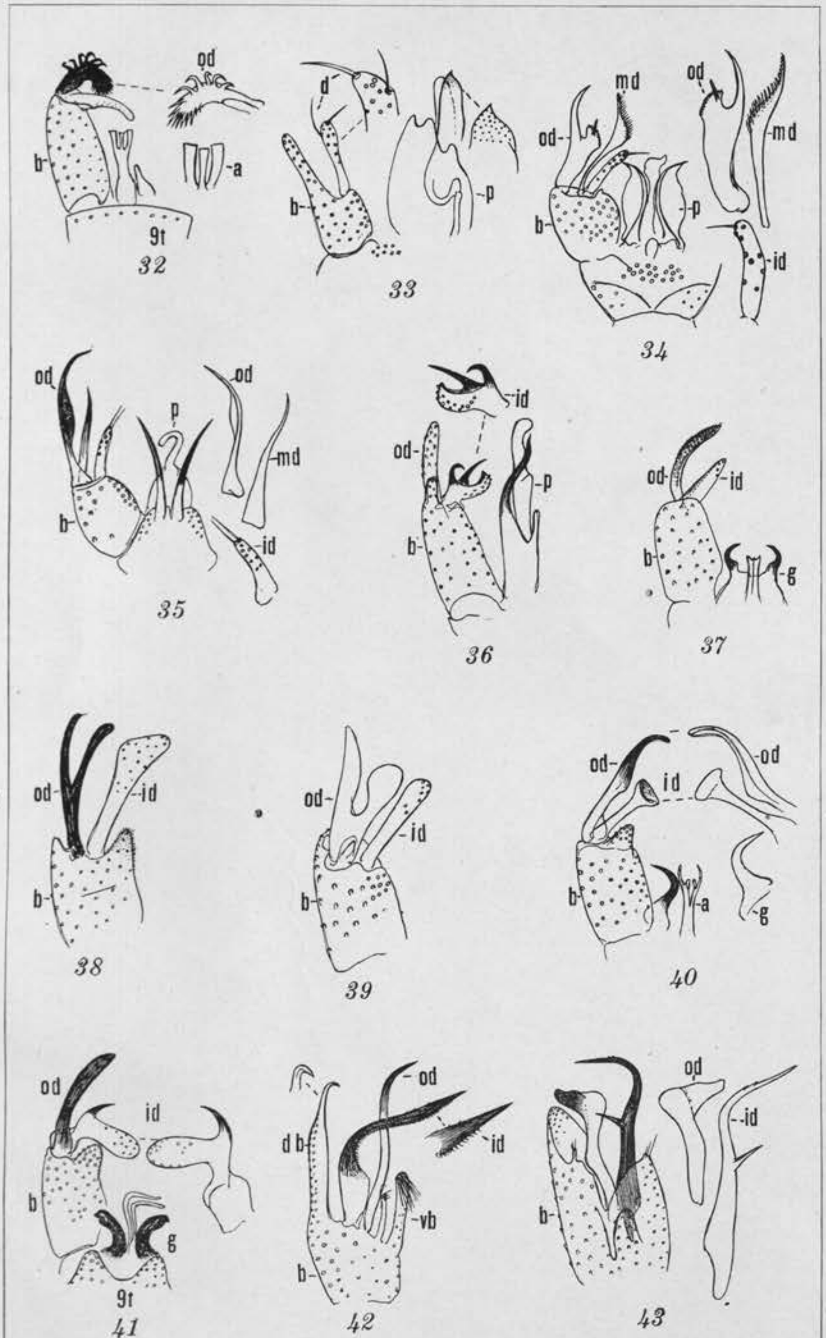
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PLATE 3.

INDEX

[New names and new combinations are printed in **boldface**.]

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